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EDITORIAL

THE STONE REJECTED

This is the stone that was set at nought of you builders * * *

It sometimes takes discernment and courage of conviction to choose and set in the proper places in a foundation the right stones. But it is most important. Rejecting the proper stone may result in an unserviceable structure. Innumerable great enterprises have been known to fail because some very insignificant, overlooked "peg was loose". Conversely, the key to success in many other great enterprises has been appreciation and proper attention to some small though essential detail.

To a man who came into my office a few days ago, I showed a little box containing a specimen of a very small blackish moth. He gave it a glance, tossed it back on the table with a contemptuous grunt, remarking, "Strange how little it takes to amuse some people! Why should any one waste his time on such things!" Why, indeed! Things are important in this world according to their relation to other things, and according to what we may know of their relation directly or indirectly to human affairs. The larva of this obscure and ordinary looking little black moth is devastating the coconut plantations of Fiji, and the government of this group of islands, in alarm, has sent abroad for men to come and study it and try to control it. Through this one extremely insignificant thing, the chief source of income of Fiji is imperiled. We have another moth, in Mindanao, which may, on occasion, be nearly as bad, and which may some day spread all over this Archipelago, but no effective steps whatever are being taken to avoid such an eventuality.

Early in the eighties, patches of yellow powdery material appeared on the leaves of coffee in Ceylon, quite too insignificant to deserve the attention of any reasonable man, especially a "practical business-man", in those days. If solemnly smug boards of directors had been asked to contribute to the expense of technical study of this thing, they would undoubtedly have turned it down—as many boards of directors and legislatures do yet—or adopted the "watchful waiting", *laissez faire* policy which still characterizes both boards of directors and legislatures—except, I may possibly say, in Hawaii. The insignificant "yellow powder" destroyed all the coffee in Ceylon and then spread, with tremendously destruc-

tive power, through all the Orient, even destroying the rapidly growing and very profitable coffee industry of the Philippines. The stone of competent investigation was rejected by the builders of the Ceylon coffee industry.

Not many years ago a few plants of water-hyacinth were first brought to the Philippines as house plants. Two very competent botanists in government employ protested and asked for the immediate destruction of the first few plants and permanent exclusion for the future. The water-hyacinth is an aquatic pest of the highest order of virulence and incorrigibility and has been an extremely serious and expensive problem in many other countries. These technical men were laughed at by officials approached. No accounting for the damfoolishness of these scientific cranks! Why couldn't they leave in peace people who wanted to keep a few nice house plants! Time passed and the plant escaped into the waterways about Manila, which are now clogged with water-hyacinth. It is spreading in Laguna de Bay on an immense scale and interfering with navigation. It is now scattered throughout the Archipelago—long past the stage when it can ever be exterminated. Impractical and useless "experts"! Parasites on the body politic!

We have a bud-rot of coconut in the Philippines which is destroying more and more of our trees. Much money has been spent in attempts to control it, —by cutting trees down and burning them. And all the while, of the most essential point in the whole matter we are in complete ignorance, and so far as I know no steps whatever are being taken to dispel this ignorance—ignorance of how the disease passes from one tree to another. In this, we are in the same helpless situation that sanitarians were in before it was known how malaria passed from one person to another, and in those days all the recommendations of all the doctors in Christendom did not avail to control the ravages of malaria anywhere in the world. Light on the one essential point made the control of malaria easy.

We have some abaca diseases and pests which appear to be serious. We dashed into empirical methods of control before taking any effective steps whatever toward acquiring full and detailed knowledge. All of the technical methods, skill, and knowledge, that are required to investigate a human disease are quite as necessary in the case of a plant disease. Will our government have the wisdom to recognize this in time? Perhaps, in good classical style, we will wake up and buy an ornamental patent lock for the barn door—*after* the horse is stolen.

In the Philippines we constantly lose from five to above fifty per cent of the entire rice crop from preventable causes. And I am told that some eighteen million pesos worth of rice will be bought this year from a country with which we do not have reciprocal trade! Yet I am not aware that any active and competent attention is being given to these problems, with such support as will bring about any ameliorating results. It is difficult to apply fitting terms to such a policy—or rather lack of policy—when this Archipelago is a natural rice country of tremendous potentialities.

We spend hundreds of thousands of pesos annually for the purely superficial and palliative treatment of the locust problem, permitting yearly loss to the people of the country of hundreds of thousands of pesos more in crops and labor, without ever having come yet to any serious consideration of the essential

factors at the bottom of the whole matter, and solely on which any permanent relief must depend. Yet a few tens of thousands of pesos plus the *right men*, would clarify the whole problem and concentrate attention and effort on the basic details by which hang any possibility of permanent relief. But the stone lies rejected.

A country whose builders set at nought the stone of technical investigation along all scientific lines underlying agriculture, can hope for no safety, no real stability. And these lines must be developed symmetrically, one is as important as another. The neglected one may involve the very factors which some day will bring the house down about our ears despite the fine coat of paint we have put on it, and despite all other improvements made. The only really *practical man* in Agriculture today is the man who looks *all* of these matters squarely and impartially in the face, with sufficient technical training to appreciate the interrelations of the thousand and one factors which compose the great field of Agricultural Science. The most progressive governments on earth have fully accepted this view and the richest and most soundly successful countries are conspicuous examples of its application.

In the Philippines we have as yet barely emerged from the "Dios cuidao" stage. But God's mercy is especially needed in case of *wilful* ignorance—refusal to heed the lessons so dearly learned by others, and continued rejection of the stone that would make the country's economic structure stable and safe. *The strength of any country may be justly measured by its attitude toward scientific investigation and toward the technical education which is built upon it.*

CHARLES FULLER BAKER,
Dean, College of Agriculture.

THE EFFECT OF SPACING ON TILLERING AND PRODUCTION OF THREE VARIETIES OF RICE[1]

By PEDRO A. RODRIGO

INTRODUCTION

One of the fundamental factors which affect the tillering and the yield of the rice plant (*Oryza sativa* L.) is the distance of planting. While it is admitted that the tillering and the yielding powers of the rice plant are hereditary characters, their expressions are highly affected by the factors of the environment, by the treatment of the plants and by the fertility of the soil. A number of these factors, such as treatment of the soil, spacing of the hills, and planting of different number of plants in a hill can be controlled. The study of some of these controllable factors, as spacing of seedlings at transplanting time, is very necessary in rice production.

The consensus of opinion of a number of investigators is that tillering and production of grains are affected by the distance at which the plants are set apart in the field. Whether the distance of planting rice which gives the greatest yield or the greatest number of tillers per plant is also the most profitable, is a question. Under certain conditions, closer planting may give higher yield than wider planting. But it does not necessarily follow that closer planting is also more profitable; for the difference in yield may not be more than enough to counterbalance the extra expense involved in planting more plants as a result of closer planting. It is an admitted fact that profit in practical farming is the principal aim of the farmer. The writer is not aware of any attempt to determine the most profitable distance of planting rice. Data on production and expenses as affected by different distances of planting, therefore, should prove useful to rice growers. While this study is confined only to transplanted rice, the results obtained may also throw light on broadcasted and drilled rice.

REVIEW OF PREVIOUS WORK

There are a number of workers who have investigated some of the characters of the rice plant and of some other cereals, such as barley and corn, as affected by the rate of seeding and the distribution of the hills in the field. The results, especially of those who worked on rice, are at variance. Thompstone (1), Inagaki (2), Parr (3), and Tiden (4) claim that tillering of a plant varies with the variety, the soil, the climatic conditions, and the treatment of the plants. Thompstone (1) who worked with two varieties which differ by 20 days in age of maturity, claims that short-lived varieties have less tillering power than long-lived varieties. Summers (5), who apparently studied the subject more extensively, concluded that the number of days to maturity is not a criterion of the power of the variety to produce tillers. Summers' conclusion agrees with the results of Jacobson (6) and of Vibar (7) on their correlation work on rice, in so far as varieties maturing in not less than 100 days are concerned.

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[1] Thesis presented for graduation for the degree of Master of Science in Agronomy, University of the Philippines, No. 178. Experiment Station contribution, No. 222.

Parr (3) states that "leaving out the quality of the soil and seed, the amount of space allowed to each plant is the limiting factor" of the plant's ability to tiller and to produce grains. He further says,—and in this, he is confirmed by Thompstone (1) and Tiden (4)—that the number of tillers produced per plant varies, up to a certain limit, directly with the space allowed to the individual plants. On the other hand, Parr (3) points out the danger of too wide spacing. He says that it leads to an excessive vegetative development with few and imperfectly formed grains, and to an uneven ripening which naturally interferes with harvesting.

Summers (5) in his paper on the tillering of Ceylon rice states that Graham and Jack claim that transplanting acts in a way like root pruning, and the "shock" produced stimulates the growth of the sub-aerial portion of the plant and thus results in increased tillering. Summers attributes the greater production obtained by the transplanting method partially to the "shock" factor claimed by Graham and Jack.

While Thompstone (8) of Burma, Sethi (9) of Bihar (India), and some investigators (10) at Rajshahi (India), report that close planting gives better results; yet there are a number of investigators who report the contrary. That is, setting the hills further apart, within certain limits, gave better production. The probable explanation of the difference in the results of these workers is the apparent difference in climatic and soil conditions under which their respective experiments were conducted and also the difference in the varieties or strains they used.

Warth (11) of Burma (India) and Lonsdale (12) of Madras (India) claim that by considerably reducing the customary rate of seeding by means of "single planting of paddy seedlings", they were able to effect and maintain some increase in yield per unit area. Lonsdale (12) further states that with the native method of planting (in bunch of 2-20 seedlings in a bunch), most of the varieties locally grown in the district "have partially lost their powers of tillering". He claims, however, that the same varieties, when planted singly, gradually regained their power to tiller.

Dobbs (13) reports that at the rate of one seedling to the hill, a greater five-year average yield than transplanting at the rate of two, three or four seedlings per hill was obtained. The distance in which the hills were set apart was not given. McGowan (14) reports that "transplanting 18 inches apart (four seedlings per hill) seemed preferable to six, nine or 12 inches apart." He states further that the production of hills planted with one seedling equaled or exceeded that of the hills planted to two, four or six seedlings when treated heavily with barnyard manure.

Thompstone (1) asserts that "as the tillers increase, there is an increase in the weight of the grains, but this increase is not in direct proportion to the number of tillers produced by the plant". Hector (15) in his 1920-21 report to the Government of Bengal, concludes that spacing has a great influence on the num-

ber of tillers and the number of grains per tiller but has almost no effect on the weight of the individual grains. He also states that "early transplantation of single seedlings, spaced 12 inches apart, yields most when equal number of plants is considered, but this increase in yield is more than compensated for by the few number of plants when equivalent areas are considered."

Jacobson (16), formerly of the Philippines Bureau of Agriculture, claims that single seedlings set at 10 centimeters apart each way have ample space for normal development and that they could not utilize a greater area. He further claims that setting the hills at 20 by 20 centimeters with four plants in a hill proved practical. Cazeñas (17) who conducted a similar experiment in the Philippines College of Agriculture reports that single seedlings set at 30 by 30 centimeters gave better production than either a distancing of 15 by 15 centimeters, 20 by 20 centimeters or 25 by 25 centimeters. Cazeñas' experiment, however, was conducted on newly constructed paddies where the natural contour of the field was greatly changed. The condition of the field, together with the lack of control plots to correct the variability of the soil, throw doubt as to the significance of the differences in yield between the different spacings.

OBJECT OF THE PRESENT WORK

The object of this study was (a) to determine the effect of spacing on tillering and production of three lowland varieties of rice and (b) to find the feasibility of introducing *breeding plat* for mass selection under the present method of rice culture in the Philippines. In connection with the second object, it should be remembered that the native method of planting rice is in bunch with about from one to fifteen plants in a bunch or in a hill. Consequently, when one selects a hill which has many fruiting culms, he is not necessarily selecting a plant that is supposed to be productive because the hill referred to may be composed of several plants. Hence the difficulty of carrying mass selection effectively.

TIME AND PLACE OF THE PRESENT WORK

The preliminary part of this investigation was conducted during 1922-1923. The major part which furnished the data reported in this study was performed during the rice season of 1923-1924. The experiment was conducted in the rice paddies behind the Sugar Mill of the Philippines College of Agriculture.

MATERIALS AND METHODS

VARIETIES USED

Three lowland varieties which are being grown in the College were used in this study. These are variety Daluson[2], variety Murmuray[3], and variety Diquet a Bolilising[4]. These varieties appear highly homogeneous.

Three paddies were used, each divided into nine plots of the same size and shape. The plots were rectangular and each had an area of not less than 42 square meters. The check plots were located at every fourth plot as shown in Table I. Table I also shows the distances of planting and the number of seedlings planted in a hill.

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[2] Daluson bears the College Number, 17565.

[3] Murmuray bears the College Number, 17567.

[4] Diquet a Bolilising bears the College Number, 5896.

TABLE I.—*Spacing the experimental plots.*

Variety used and paddy number.	Plot number.	Spacings.	Number of plants per hill.	Number of hills per square meter.
		cm.		
	1[a]	20×20[b]	3[b]	25.00
	2	10×10	1	100.00
	3	15×15	1	44.44
Daluson	4	20×20	1	25.00
	5[a]	20×20[b]	3[b]	25.00
I	6	25×25	1	16.00
	7	30×30	1	11.11
	8	40×40	1	6.25
	9[a]	20×20[b]	3[b]	25.00
	1[a]	20×20[b]	3[b]	25.00
	2	10×10	1	100.00
	3	15×15	1	44.44
Murmuray	4	20×20	1	25.00
	5[a]	20×20[b]	3[b]	25.00
II	6	25×25	1	16.00
	7	30×30	1	11.11
	8	40×40	1	6.25
	9[a]	20×20[b]	3[b]	25.00
	1[a]	20×20[b]	3[b]	25.00
	2	10×10	1	100.00
Diquet a	3	15×15	1	44.44
Bolilising	4	20×20	1	25.00
	5[a]	20×20[b]	3[b]	25.00
III	6	25×25	1	16.00
	7	30×30	1	11.11
	8	40×40	1	6.25
	9[a]	20×20[b]	3[b]	25.00

[a] Check plots.
[b] Averages of the distance between hills and number of plants in a hill.

METHOD OF PLANTING

In order to minimize personal error in distancing, guide lines were used. This method apparently shows that more time was spent than is needed to plant a given area, without guide lines. Except in the case of the check plots, where the local method of planting was employed, and where the hills were set at about 20 by 20 centimeters with an average of three seedlings in a hill, only one good seedling was planted in a hill. Good seedling in this case refers to one that has a fairly well developed stem. The time spent in planting each plot was taken. By "planting" in this case is meant the usual planting operation plus the additional work of separating the seedlings individually before planting. This fact should be borne in mind in reading the discussion on "cost of planting."

CARE OF THE CULTURES

All vacant hills were replanted about a week after planting. The field was weeded once when the plants were about a month old in the field. Throughout the entire culture period, the different plots were treated practically the same. The irrigation water was maintained during the whole growing season.

CHECK PLOTS

In order to minimize as much as possible the experimental error due to the variability of the soil fertility, the standard deviations expressed in percentage of the yield and of the number of fruiting culms per hill of the different check plots for each variety were determined. As is shown in Table I, there were three check plots for each variety, and these plots were located in the different

parts of the paddies. Among other things, the standard deviation of the check plots shows the variability of the fertility of the soil as expressed in the tillering and yielding power of the plants.

EXPERIMENTS AND RESULTS

NUMBER OF GRAINS IN A LITER OF PALAY

The average number of grains in a liter in each of the three varieties used was determined. This was necessary in order to be able to determine the amount of seed needed to plant a certain area with the different distances of planting used. Table II-*a* gives the computed amount and cost of seed needed to plant a hectare of the three varieties used in this experiment with different distances of planting, and Table II-*b* gives the average amount and average cost of seed needed to plant a hectare.

Table III presents the computed time spent in and the cost of planting one hectare with different spacings of hills based on the current price of Los Baños labor. Table IV is a summary of Tables II-*a*, II-*b* and III and gives the total cost of planting one hectare including the cost of seed. The relative total expenses of the different spacings are also included in Table IV.

TABLE II-*a*.—*Computed amount and cost of seed needed to plant a hectare with different distances between hills.*

Spacing.	Number of seedlings in a hill.	Computed number of seedlings needed to plant one hectare.	Computed amount of grains to plant one hectare.[a]	Computed cost of seed needed to plant one hectare.[b]
		Variety Daluson		
centimeter			*liter*	*peso*
Check[c]	3	750,000	48.93	3.26
10×10	1	1,000,000	65.25	4.35
15×15	1	444,444	28.93	1.93
20×20	1	250,000	16.31	1.09
25×25	1	160,000	10.43	0.70
30×30	1	111,111	7.25	0.48
40×40	1	62,500	4.08	0.27
		Variety Murmuray		
Check[c]	3	750,000	47.82	3.19
10×10	1	1,000,000	63.76	4.25
15×15	1	444,444	28.34	1.88
20×20	1	250,000	15.94	1.06
25×25	1	160,000	10.20	0.68
30×30	1	111,111	7.08	0.47
40×40	1	62,500	3.98	0.27
		Variety Diquet a Bolilising		
Check[c]	3	750,000	61.32	4.09
10×10	1	1,000,000	81.75	5.45
15×15	1	444,444	36.42	2.43
20×20	1	250,000	20.44	1.36
25×25	1	160,000	13.08	0.87
30×30	1	111,111	9.08	0.61
40×40	1	62,500	5.11	0.34

[a] Average number of grains per liter:
1. Daluson—15,326.
2. Murmuray—15,684.
3. Diquet a Bolilising—12,232.

No allowance for poor seeds and poor seedlings.

[b] Current price, one cavan (75 liters) of palay in Los Baños, ₱5.00.

[c] See Table I.

TABLE II-[b].—*Average amount and cost of seed needed to plant a hectare with different distances between hills.*[a]

Distancing between hills.	Computed amount of seed needed to plant a hectare.	Computed cost of seed needed to plant a hectare.[b]
centimeter	*liter*	*peso*
Check[c]	52.68	3.51
10×10	70.26	4.68
15×15	31.23	2.08
20×20	17.55	1.17
25×25	11.25	0.75
30×30	8.40	0.56
40×40	4.38	0.29

[a] Average of three varieties.
[b] See Table II-a.
[c] See Table I.

TABLE III.—*Computed time spent in and cost of planting one hectare with different distances between hills.*

Variety Daluson

Spacing of hills.	Average number of hills per sq. meter.	Area of plots.	Time spent in planting.		Computed cost of planting one hectare.[a]
			Actual.	Computed to one hectare.	
centimeter		*sq. m.*	*hour*	*hour*	*peso*
Check[b]	25.00	54	1.60	296.3	29.63
10×10	100.00	54	14.20	2,629.6	262.96
15×15	44.44	54	4.50	833.3	83.33
20×20	25.00	54	2.83	524.1	52.41
Check[b]	25.00	54	1.67	309.3	30.93
25×25	16.00	54	2.50	463.0	46.30
30×30	11.11	54	1.75	324.1	32.41
40×40	6.25	54	1.00	185.2	18.52
Check[b]	25.00	54	1.40	259.3	25.93

Variety Murmuray

Check[b]	25.00	42	0.80	190.5	19.05
10×10	100.00	42	7.27	1,731.0	173.10
15×15	44.44	42	4.65	1,107.1	110.71
20×20	25.00	42	2.75	654.8	65.48
Check[b]	25.00	42	0.82	195.2	19.52
25×25	16.00	42	1.77	421.4	42.14
30×30	11.11	42	1.25	297.6	29.76
40×40	6.25	42	0.70	166.7	16.67
Check[b]	25.00	42	0.91	216.7	21.67

Variety Diquet a Bolilising

Check[b]	25.00	54	1.85	342.6	34.26
10×10	100.00	54	14.11	2,612.9	261.29
15×15	44.44	54	8.27	1,531.5	153.15
20×20	25.00	54	6.13	1,135.2	113.52
Check[b]	25.00	54	1.26	233.3	23.33
25×25	16.00	54	3.16	585.2	58.52
30×30	11.11	54	1.95	361.1	36.11
40×40	6.25	54	0.83	153.7	15.37
Check[b]	25.00	54	1.31	242.6	24.26

[a] Based on Los Baños labor conditions, nine hours a day at 90 centavos a day.
[b] Native method of planting; hills spaced about 20×20 cm. with about three plants per hill.

TABLE IV.—*Computed cost of planting one hectare, and cost of seed planted.*

Spacing of hills.	Expenses.			
	Computed cost of planting one hectare.[a]	Computed cost of seed planted in one hectare.[b]	Total expenses.	Relative.[c]
centimeter	*peso*	*peso*	*peso*	
Check[d]	25.40	3.45	28.85	100.00
10×10	232.45	4.68	237.13	821.94
15×15	115.73	2.08	117.81	408.35
20×20	77.14	1.17	78.31	271.43
25×25	48.99	0.75	49.74	172.41
30×30	32.76	0.52	33.28	115.36
40×40	16.85	0.29	17.14	59.41

[a] See Table III.

[b] See Table II.

[c] The check plots taken as standard is assigned a value of 100.

[d] See Table I.

FIELD OBSERVATIONS

The effect of weeds and insect enemies were especially noted during the early growth of the plants. The effect of the rice Nymphalid (*Melanitis ismene* Cram.), which is sometimes very prevalent in rice fields when the plants are young, was more severe in the plots where the hills were set further apart. However, the plants were able to recover completely from the attack of this pest.

The growth and distribution of weeds throughout the field were practically uniform. It was found, however, that it was very much easier to weed out the plots where the hills were set further apart. The date of flowering was slightly affected by the spacing of the plants. The plants in the plots where the hills were set at 30 by 30 centimeters and 40 by 40 centimeters headed out a few days later than those which were planted more closely.

EFFECT OF SPACING ON TILLERING

Tables V-*a*, and V-*b*, and V-*c* give the average number of fruiting culms of 250 hills and the distribution of these hills according to the number of fruiting culms which each hill has as affected by the distance at which the hills were set. The means, the standard deviations and the average deviations of the number of fruiting culms in a hill of the check plots of the varieties under study, are given in Table VI. Table VII is a summary of Tables V-*a*, V-*b*, and V-*c* and Table VI. It shows the relative power of the plants to produce tillers as affected by different spacings.

TABLE V-[a].—*Frequency distribution of the average number of fruiting culms in a hill of variety Daluson as affected by spacing.*

Number of bearing culms in a hill.	Distances each way between hills in centimeters.								
	Check.[a]	10	15	20	Check.[a]	25	30	40	Check.[a]
Class value					*frequency*				
1	21	96	29	23	30	10	1	0	15
2	73	115	91	76	66	24	5	2	39
3	77	28	99	81	73	36	14	2	66
4	40	11	22	48	39	50	27	5	53
5	30	0	9	13	20	51	30	11	30
6	5	0	0	7	10	42	40	13	26
7	2		0	2	8	17	33	15	13
8	1			0	4	14	30	17	7
9	1			0	0	5	23	20	1
10	0				0	1	18	29	0
11	0					0	12	25	0
12						0	8	23	
13							4	18	
14							2	17	
15							1	14	
16							1	10	
17							0	9	
18							1	8	
19							0	5	
20							0	4	
21								2	
22								0	
23								0	
24								0	
25								1	
26								0	
Mean and probable error.	3.08 ±0.06	1.82 ±0.03	2.56 ±0.04	2.92 ±0.05	3.14 ±0.07	4.64 ±0.08	7.06 ±0.12	11.22 ±0.18	3.86 ±0.07

[a] See Table I.

TABLE V-*b*.—*Frequency distribution of the number of fruiting culms in a hill of variety Murmuray as affected by spacing.*

Number of bearing culms in a hill.	Distances each way between hills.								
	Check.[a]	10 cm.	15 cm.	20 cm.	Check.[a]	25 cm.	30 cm.	40 cm.	Check.[a]
Class value					*frequency*				
1	16	140	71	21	20	6	3	0	6
2	35	98	105	46	25	16	6	3	19
3	46	11	60	66	53	28	12	8	27
4	49	1	11	52	58	32	23	10	36
5	44	0	3	36	45	35	31	13	45
6	20	0	0	19	29	48	34	14	42
7	18		0	4	13	29	36	15	31
8	14			3	5	23	33	16	21
9	4			1	1	13	22	16	11
10	4			1	1	9	19	17	8
11	0			0	0	6	12	21	3
12	0			1	0	3	9	23	1
13				0		1	5	22	0
14				0		1	2	17	0
15						0	2	15	
16						0	0	10	
17							1	7	
18							0	6	
19							0	5	
20								5	
21								3	
22								2	
23								1	
24								1	
25								0	
Mean and probable error.	4.30 ±0.09	1.49 ±0.03	2.08 ±0.04	3.58 ±0.07	4.04 ±0.07	5.74 ±0.11	7.14 ±0.12	10.95 ±0.20	5.42 ±0.10

[a] See Table I.

TABLE V-c.—*Frequency distribution of the number of fruiting culms in a hill of variety Diquet a Bolilising as affected by spacing.*

Number of bearing culms in a hill.	Distances each way between hills.								
	Check.[a]	10 cm.	15 cm.	20 cm.	Check.[a]	25 cm.	30 cm.	40 cm.	Check.[a]
Class value					*frequency*				
1	12	98	64	13	8	9	4	0	5
2	24	118	84	38	23	24	7	2	20
3	33	30	68	68	41	31	18	7	27
4	41	3	22	46	54	46	19	9	34
5	47	1	9	43	49	51	21	9	39
6	27	0	2	23	29	29	24	10	42
7	22	0	1	15	20	28	29	14	29
8	17		0	5	11	15	31	17	27
9	12		0	3	7	10	21	18	13
10	8			0	4	3	16	19	7
11	3			0	1	2	14	19	4
12	2				1	1	13	20	2
13	1				1	1	10	25	0
14	1				1	0	8	19	1
15	0				0	0	5	15	0
16	0				0		5	12	0
17							3	7	
18							1	6	
19							1	5	
20							0	4	
21							0	3	
22								3	
23								2	
24								2	
25								1	
26								1	
27								0	
28								1	
Mean and probable error.	5.13 ±0.11	1.76 ±0.03	2.35 ±0.05	3.96 ±0.07	4.77 ±0.09	4.98 ±0.09	7.97 ±0.16	11.65 ±0.21	5.59 ±0.10

[a] See Table I.

TABLE VI.—*The mean and standard and average deviations of the number of fruiting culms in a hill of the check plots.*

Variety Daluson.

Plot umber.	(V) Average number of fruiting culms.	Per cent.
I	3.08	
V	3.14	
IX	3.86	
Total	10.08	
Mean	3.39±0.14	
Standard deviation	0.36±0.10	10.62±2.95
Average deviation	0.34	10.29

Variety Murmuray.

I	4.30	
V	4.04	
IX	5.42	
Total	13.76	
Mean	4.59±0.23	
Standard deviation	0.60±0.17	13.07±3.70
Average deviation	0.56	12.25

Variety Diquet a Bolilising.

I	5.13	
V	4.77	
IX	5.57	
Total	15.47	
Mean	5.16±0.13	
Standard deviation	0.33±0.10	6.41±1.94
Average deviation	0.28	5.43

TABLE VII.—*Average and relative number of fruiting culms per hill as affected by different distances between plants.*

Spacing of hills.	Average number of fruiting culms in a hill.	Relative number of fruiting culms.[a]
Variety Daluson		
centimeter		
Check[b]	3.39	100.00
10×10	1.82	53.69
15×15	2.56	75.52
20×20	2.92	86.13
25×25	4.64	136.87
30×30	7.06	208.26
40×40	11.22	330.97
Variety Murmuray		
Check[b]	4.59	100.00
10×10	1.49	32.46
15×15	2.08	45.32
20×20	3.58	78.00
25×25	5.74	125.05
30×30	7.14	155.56
40×40	10.95	238.56
Variety Diquet a Bolilising		
Check[b]	5.16	100.00
10×10	1.76	34.11
15×15	2.35	45.54
20×20	3.96	76.74
25×25	4.98	96.51
30×30	7.97	154.46
40×40	11.65	225.78

[a] The check which is taken as standard is assigned a value of 100.

[b] See Table I.

TABLE VIII.—*Actual and relative yields as affected by spacing.*

Spacing of hills.	Yield.	
	Actual.	Relative.[a]
centimeter	*liter*	
Variety Daluson		
Check[b]	25.88	100.00
10×10	20.95	80.95
15×15	21.32	82.38
20×20	23.62	91.27
25×25	24.42	94.36
30×30	27.37	105.76
40×40	22.50	86.94
Variety Murmuray		
Check[b]	26.34	100.00
10×10	22.24	84.43
15×15	23.85	90.50
20×20	24.05	91.30
25×25	25.51	96.85
30×30	26.47	100.50
40×40	18.72	71.07
Variety Diquet a Bolilising		
Check[b]	27.68	100.00
10×10	24.00	86.71
15×15	24.78	89.52
20×20	26.14	94.44
25×25	27.40	99.00
30×30	23.19	83.78
40×40	20.50	74.06

[a] See Table VII.

[b] See Table I.

TABLE IX.—*The mean, and standard and average deviations of the yields of the check plots.*

Variety Daluson

Plot number.	(V) Yield.	Per cent.
	kilogram	
I	25.36	
V	24.00	
IX	28.27	
Mean	25.88±0.69	
Standard deviation	1.78±0.49	6.87±1.90
Average deviation	1.60	6.18

Variety Murmuray

I	26.79	
V	24.30	
IX	27.92	
Mean	26.34±0.58	
Standard deviation	1.51±0.42	5.73±1.59
Average deviation	1.36	4.87

Variety Diquet a Bolilising

I	27.82	
V	26.10	
IX	29.12	
Mean	27.68±0.48	
Standard deviation	1.24±0.34	4.84±1.23
Average deviation	1.05	4.16

TABLE X.—*Computed yield and number of fruiting culms per square meter.*

Spacing of hills.	Computed number of fruiting culms in one square meter.	Average yield of one square meter.
centimeter		*liter*
Variety Daluson		
Check[a]	84.75	0.48
10×10	182.00	0.38
15×15	113.77	0.39
20×20	73.00	0.44
25×25	74.24	0.45
30×30	78.44	0.51
40×40	70.13	0.41
Variety Murmuray		
Check[a]	114.75	0.63
10×10	149.00	0.53
15×15	92.44	0.57
20×20	89.50	0.57
25×25	91.84	0.61
30×30	79.33	0.63
40×40	68.24	0.45
Variety Diquet a Bolilising		
Check[a]	129.00	0.51
10×10	176.00	0.44
15×15	104.43	0.46
20×20	99.00	0.48
25×25	79.68	0.51
30×30	88.55	0.43
40×40	72.81	0.38

[a] See Table I.

TABLE XI.—*Relative cost of planting and relative production as affected by spacing.*

Spacing of hills.	Relative cost of planting and of seeds.	Relative production.
	Variety Daluson	
centimeter		
Check.[a]	100.00	100.00
10×10	821.94	80.95
15×15	408.35	82.38
20×20	271.43	91.27
25×25	172.41	94.36
30×30	115.36	105.76
40×40	59.41	86.94
	Variety Murmuray	
Check.[a]	100.00	100.00
10×10	821.94	84.43
15×15	408.35	90.50
20×20	271.43	91.30
25×25	172.41	96.85
30×30	115.36	100.50
40×40	59.41	71.07
	Variety Diquet a Bolilising	
Check[a]	100.00	100.00
10×10	821.94	86.71
15×15	408.35	89.52
20×20	271.43	94.44
25×25	172.41	99.00
30×30	115.36	83.78
40×40	59.41	74.06

[a] See Table I.

TABLE XII.—*Computed yield of and cost of seed and in planting one hectare.*

Spacing.	Average yield per square meter.	Computed yield per hectare.	Computed cost of yield per hectare.[a]	Expenses in planting one hectare.	Value of yield (at ₱5.00 per cavan) minus cost of seed and labor of planting.
centimeter	*liter*	*cavan*[c]	*peso*	*peso*	*peso*
Variety Daluson					
Check[b]	0.48	64.00	320.00	28.85	291.15
10×10	0.38	50.67	253.35	237.13	16.22
15×15	0.39	52.00	260.00	117.81	142.19
20×20	0.44	58.67	293.35	78.31	214.04
25×25	0.45	60.00	300.00	49.74	250.26
30×30	0.51	68.00	340.00	33.28	306.72
40×40	0.41	54.67	273.35	17.14	256.21
Variety Murmuray					
Check[b]	0.63	84.00	420.00	28.85	391.15
10×10	0.53	70.66	353.35	237.13	116.22
15×15	0.57	76.00	380.00	117.81	262.19
20×20	0.57	76.00	380.00	78.31	301.69
25×25	0.61	81.34	406.70	49.74	356.96
30×30	0.63	84.00	420.00	33.28	386.72
40×40	0.45	60.00	300.00	17.14	282.86
Variety Diquet a Bolilising					
Check[b]	0.51	68.00	340.00	28.85	311.15
10×10	0.44	58.67	293.35	237.13	56.22
15×15	0.46	61.34	306.70	117.81	188.89
20×20	0.48	64.00	320.00	78.31	241.69
25×25	0.51	68.00	340.00	49.74	290.26
30×30	0.43	57.34	286.70	33.28	253.42
40×40	0.38	50.67	253.35	17.14	236.21

[a] See Table II-*a*.

[b] See Table I.

[c] One cavan is equal to 75 liters.

EFFECT OF SPACING ON PRODUCTION OF GRAINS

Table VIII gives the actual as well as the relative yields of the different spacings of all the varieties used. Table IX gives the means, and the standard and average deviations of the yields of the check plots. Table X gives the computed number of fruiting culms and the average yield of one square meter of the three varieties in question as affected by different spacings. This table is based on Tables V-*a*, V-*b* and V-*c*, and Table VIII.

Table XI presents the relative cost of planting, including cost of seed and the relative production as affected by different spacings. This table is a summary of Tables IV and VIII. Table XII gives the computed cost of the crop per hectare of the different plots which were planted with different spacings.

DISCUSSION OF RESULTS

COST OF SEED

The amount of seed of any particular variety of rice which is needed to plant a given area depends on the distance at which the hills are set apart in the field and the number of plants set in a hill. It also depends upon the size of the grains. The large seeded varieties would naturally require more seed (in volume) to plant a given area, all other things being equal. Table II-*a* shows that where

the hills were set closer in the field, more seedlings were needed to plant a unit area. It is seen that where the hills were set at 10 centimeters apart each way with one seedling to the hill, an average of 100 "good" seedlings were needed to plant one square meter. When set at 15 centimeters apart each way, an average of 44.44 seedlings were needed; when set at 20 centimeters, 25 seedlings; at 25 centimeters, 16 seedlings; at 30 centimeters, 11.11 seedlings; and at 40 centimeters, 6.25 seedlings were needed.

Lonsdale (12) reports that the native rate of seeding in India is being considerably reduced without experiencing any decrease in production. In the Philippines no actual determination of the rate of seeding has been made. However, it is generally accepted that one cavan of palay is the average approximate amount needed to plant one hectare. This would mean that about 1,681,430[1] cavans (1,261,072.5 hectoliters) are used annually for the whole area devoted to rice in the Philippines. Table II-*b* shows that with one plant to the hill, the amounts of 17.56, 23.42, 10.41, 5.85, 3.75, 2.81 and 1.46 gantas (52.68, 70.26, 31.23, 17.55, 11.25, 8.43 and 4.38 liters) of palay were needed to plant a hectare when the hills were set at 10, 15, 20, 25, 30 and 40 centimeters apart each way, respectively. Based on this rate and giving an allowance of 20 per cent for wasted seed and seedlings, it would require about 302,658 cavans (226,993.5 hectoliters) of palay seed annually to plant the whole rice area in the Philippines if the hills are set at 25 centimeters apart each way, and 225,984 cavans (169,488 hectoliters) if the hills are set 30 centimeters apart each way. This would give an annual saving to the Filipino rice farmers of about 1,378,772 cavans (1,034,079 hectoliters) or 6,893,865 pesos[2] and 1,455,446 cavans (1,091,584.5 hectoliters) or 7,277,230 pesos if the hills are set at 25 and 30 centimeters apart each way, respectively. The annual saving if expressed in percentage would run as high as 82 per cent when the hills are set at 25 centimeters apart each way; when set at 30 centimeters, it would run as high as 86.5 per cent.

To avoid the wasting of too many seedlings during transplanting period because of the fine stems of the seedlings, and to enable the planter to separate the seedlings easier, the seeds should be planted thinly in the seed bed so that more sturdy seedlings may be obtained. The Filipino farmer, apparently, is inclined to plant more seedlings than are necessary in a hill because the stems are thin and weak as the seedlings grow in a comparatively crowded condition.

COST OF PLANTING

Table III gives the computed time spent in planting one hectare, and the cost, with different distances of planting for the three varieties studied. In order to have more reliable data on cost of planting one hectare with different distances of planting, the averages of the three varieties studied were taken. The averages are given in Table IV. As shown in this table, the cost of planting one hectare was ₱232.45 when hills were set 10 centimeters apart each way. When the hills were set 15 centimeters apart each way, the cost of planting per hectare was ₱115.73; when the hills were set at 20 centimeters apart, the cost was ₱77.14; at 25 centimeters, it was ₱48.99; at 30 centimeters, it was ₱32.76; and at 40 centimeters, it was ₱16.85. It is also shown in Table III that the plots

[1] See Table XXV, Statistical Bulletin No. 5. Manila. 1923.
[2] See Table II-*a*.

where the hills were set closer together did not only require more seedlings but they also needed more time to plant a given area, hence greater expense, as is shown in Table IV. The expenses in planting a given area where the hills were set at 10 and 15 centimeters apart each way were very much greater than those of the other distances of planting. Hence it is apparent that there must be a very much greater yield over the plots which were planted rather sparsely to balance the extra expense in planting more seedlings because of closer planting.

The data on the cost of planting presented in Table IV are rather high. This was because guide lines were used in transplanting. The expenses as reported may be reduced about 70 or 60 per cent if guide lines are not used or down to about 80 per cent if guide lines are established only at reasonable intervals.

EFFECT OF WEEDS

The distance between hills did not affect the distribution and the growth of weeds during the early growth of the plants. A possible explanation for this is that the plants were too small to do any damage to the weeds which sprouted. The weeding out, however, was more difficult where the hills were set closer. While the amount of weeds from the same areas might have been the same, the plants in the closer planting prevented the free movement of the weeder, hence decreasing his efficiency. On the other hand, he was able to move freely in the plots where the plants were set further apart, thus enabling him to cover a larger area per unit of time.

EFFECT OF DISTANCE OF PLANTING ON DATE OF FLOWERING

The date of flowering was slightly affected by the distance at which the plants were set apart in the field. With all the three varieties used, the plants in the plots where the hills were set at 30 centimeters and 40 centimeters apart each way headed out a few days later. Also the range of flowering season was longer in the plots where the hills were set at 40 centimeters apart each way. In these particular plots, as will be discussed later, the tillering of the plants was more free and the growth in general was more vigorous. The rather excessive vegetative growth may account for the delay in, and the greater unevenness of, flowering as was also found by Parr (3). He claims that "research of the last forty years has shown, that, if a certain maximum of space is exceeded, undesirable results will follow, because the plant tends to continue its vegetative development when the whole of its attention is required for the formation of seeds." This is naturally so because the tillers which are produced last are frequently only partly developed when the seeds of the older tillers are ripening. According to Summers (5), when the plants are set rather far apart, three sets of tillers may arise, in which case, the tillers produced during the third phase produce smaller panicles. It is also apparent that tillers produced during the third phase mature later than the culms produced earlier.

EFFECT OF DISTANCE OF PLANTING ON TILLERING

Table XIII, a summary of Tables V-*a*, V-*b* and V-*c*, gives the average number of fruiting culms per plant as affected by the distance of planting.

TABLE XIII.—*Showing the average number of fruiting culms per hill as affected by distance of planting.*

Variety name.	Distances each way between hills.					
	10 cm.	15 cm.	20 cm.	25 cm.	30 cm.	40 cm.
Daluson.....	1.82±0.03	2.56±0.04	2.92±0.05	4.64±0.08	7.06±0.12	11.22±0.18
Murmuray.....	1.49±0.03	2.08±0.04	3.58±0.07	5.75±0.11	7.14±0.12	10.95±0.20
Diquet a Bolilising.....	1.76±0.03	2.35±0.05	3.96±0.07	4.98±0.09	7.97±0.16	11.65±0.21

It is shown in Table XIII that with any of the three varieties studied, the average number of fruiting culms per plant varied with the distance at which the plants were set in the field. The greater the space allowed to each plant, the greater was the number of fruiting culms produced. This agrees with the findings of Cazeñas (17), of Hector (15), and of Tiden (4).

Considering the average number of fruiting culms of the check plots of the variety as standard for that variety and with a value of 100, and then reducing the average of the different distances of planting to their relative values, the significance of the differences is made apparent. These relative values are presented in Table XIV. In this connection, it may be mentioned that any difference between any two distances of planting which is less than the standard deviation expressed in percentage of the average of the check plots is considered insignificant and any difference greater than the standard deviation is considered significant. Judged in this light, the differences between the average number of fruiting culms of the different spacings of the three varieties used were significant. In other words, the physiological expression of the tillering power of the rice plant was made greater by the wider space between the hills.

TABLE XIV.—*Showing the relative stooling power of the three varieties studied, as affected by the distance of planting.*

Variety name.	Distances each way between hills.						
	Check.	10 cm.	15 cm.	20 cm.	25 cm.	30 cm.	40 cm.
Daluson.....	100	53.69	75.52	86.13	136.87	208.26	330.97
Murmuray.....	100	32.46	45.32	78.00	125.05	155.56	238.56
Diquet a Bolilising.....	100	34.11	45.64	76.74	96.51	154.46	225.78

Tables V-*a*, V-*b* and V-*c* further show that the distribution of the plants from a particular plot according to the number of fruiting culms produced by one plant, depended upon the space allowed to each plant and the number of plants in each hill. The greater the space allowed to each plant, the greater was the range of the number of fruiting culms produced by each plant. This was true with the three varieties studied as shown in Table XV.

TABLE XV.—*Showing the range of variability of the number of fruiting culms produced by one plant as affected by distancing.*

Variety name.	Distances each way between hills.						
	Check.	10 cm.	15 cm.	20 cm.	25 cm.	30 cm.	40 cm.
Daluson.....	1–9	1–4	1–5	1–7	1–10	1–18	2–25
Murmuray.....	1–12	1–4	1–5	1–12	1–14	1–17	2–24
Diquet a Bolilising.....	1–14	1–5	1–7	1–9	1–13	1–19	2–28

With the above data, and in connection with *breeding plat* for rice mass selection, the hills should not be set closer than 20 by 20 centimeters. Setting the plants closer would not allow the plants to tiller freely, thus the apparently better stooling strains would not be able to show their real capacity to tiller. On the other hand, if the plants are set farther apart, the better stooling strains could show up more thus resulting in a greater variation in the tillering of the plants. Consequently, the chances of isolating the better strains by selecting the heavier stooling plants would be very much greater.

EFFECT OF DISTANCE OF PLANTING ON YIELD

As shown in Table VIII, the yield was greatly affected by the distance at which the plants were set apart in the field. The effect of the distance of planting was, however, not so marked on the yield as on the tillering. Considering the average yield of the check plots of one variety as standard for that variety and assigning it a value of 100, the relative values of the other plots were determined. Table XVI, a summary of Table VIII, shows the relative producing power of the three varieties when set in the field at different distances between hills.

TABLE XVI.—*Showing the relative producing power of the three varieties used as affected by spacing.*

Variety name.	Distances each way between hills.						
	Check.	10 cm.	15 cm.	20 cm.	25 cm.	30 cm.	40 cm.
Daluson.....	100	80.95	82.38	91.27	94.36	105.78	86.94
Murmuray....	100	84.43	90.50	91.30	96.85	100.50	71.07
Diquet a Bolilising.....	100	86.71	89.52	94.44	99.00	83.78	74.06

The distances which gave the greatest yields and which have significant differences over the other distances of planting are 25 by 25 centimeters for Diquet a Bolilising and 30 by 30 centimeters for Daluson and Murmuray, the relative producing powers being 99.00 for Diquet a Bolilising, and 105.78 and 100.50 for Daluson and Murmuray respectively. In this connection it may be mentioned that the standard deviation expressed in percentage of the yields of the check plots for the three varieties used were determined and are given in Table IV. The standard deviations of the check plots for Daluson was 6.87 ± 1.90 per cent; for Murmuray, 5.73 ± 1.59 per cent; and for Diquet a Bolilising, 4.84 ± 1.23 per cent. Before any difference between any two distances of planting is considered significant, the difference must be greater than the standard deviation.

In general, the results thus far obtained show that the yield increased (up to a certain limit) as the distance at which the hills were set was increased, the optimum being 25 by 25 centimeters for Diquet a Bolilising and 30 by 30 centimeters for Daluson and Murmuray. These results show that under a given set of conditions, a definite distancing of hills is essential in order to obtain the maximum yield. It is, of course, impossible to lay down fast rules to follow in planting rice at different distances, but with the three varieties used, it may be stated that under Los Baños conditions, it would be practical and beneficial to set the hills from 25 centimeters to 30 centimeters apart each way with one plant to the hill. These spacings would ensure ample space for the development of the plants

without at the same time inducing excessive vegetative growth which oftentimes results in poor yield and difficulty in harvesting. Moreover, the labor in planting and the cost of seed planted are greatly reduced.

It may be asked in this connection: What is the increase in yield due to? Is it due to the increase in the number of fruiting culms per unit area, to the size of the grains or to the size of the panicles? To answer this question, the number of fruiting culms per square meter under the different distances of planting was computed. The result of the calculation is shown in Table X. The table shows that, in general, the number of fruiting culms per unit area decreased as the space between plants was made wider. In Tables V-*a*, V-*b* and V-*c*, it is shown that the number of fruiting culms per hill increased as the space between plants was made wider. Daluson in the 10 by 10 centimeter planting produced an average of 182 fruiting culms per square meter; Murmuray, 149; and Diquet a Bolilising, 176. The 30 by 30 centimeter planting in the case of Daluson and Murmuray and the 25 by 25 centimeter planting in the case of Diquet a Bolilising—the distances of planting which gave the highest production—produced on the average 78.44 fruiting culms per square meter for Daluson, 79.33 for Murmuray, and 79.68 for Diquet a Bolilising. In other words, the distancings which gave the highest production, for example, 25 by 25 centimeters for Diquet a Bolilising and 30 by 30 centimeters for Daluson and Murmuray, had a smaller number of fruiting culms per unit area than either the 10 by 10 centimeter or 15 by 15 centimeter planting. These last distancings also gave less production. The increase in yield, therefore, must either be due to an increase in the size of the grains or to an increase in the number of grains per panicle or to both. In this connection it may be mentioned that Hector (15) reported that the space allowed to each plant had no effect on the size and weight of the grain. Should this be true, the increase in yield must be due to the increase in the number of grains per panicle. It is therefore apparent that setting the plants at a distance of 30 centimeters apart each way for Daluson and Murmuray and 25 centimeters each way for Diquet a Bolilising did not only produce more fruiting culms per plant but also produced more vigorous and larger culms which in turn produced larger panicles.

Jacobson (16) found that plants set at 10 centimeters apart each way had ample space for full development. Cazeñas (17) found that a 30 by 30 centimeter distancing for variety Binicol gave the best yield. The effect on yield as reported in this paper confirms the results obtained by Cazeñas.

The question of the space allowed each plant undoubtedly depends upon the variety, the fertility of the soil, and upon the factors of the environment. But while it has been found by some investigators that close planting gave better yield in the case of some varieties, yet close planting is a matter that must be carefully investigated before it is applied to practical farming. An outstanding feature in this study and which should be of great interest to the rice growers is the fact that close planting requires more seed and more labor than wider planting. To set the hills less than 20 centimeters apart each way would put the farmer in a rather hazardous situation in so far as net profit is concerned. The expense incurred in transplanting rice at 10 centimeters or 15 centimeters apart each way is very much greater than that incurred in setting the plants at 25 centimeters or 30 centimeters apart each way, so that the increase in yield, if there is any, would hardly balance it.

SUMMARY OF CONCLUSIONS

(1) The space allowed to each plant up to at least 40 centimeters each way was a criterion of the tillering power of the plant. The greater the space allowed to each plant, the greater was the number of fruiting culms. When the plants were set at 10 centimeters apart each way, Daluson had as average number of fruiting culms per plant 1.82 ± 0.03, Murmuray 1.49 ± 0.03, and Diquet a Bolilising 1.76 ± 0.03. When the hills were set at 40 centimeters apart each way, Daluson increased its number of fruiting culms per plant up to 11.22 ± 0.18, Murmuray 10.95 ± 0.20, and Diquet a Bolilising 11.65 ± 0.21.

(2) Among the six distances of planting (10, 15, 20, 25, 30 and 40 centimeters apart each way) and with one plant per hill, the setting of plants at 30 centimeters apart each way gave the best yield for Daluson and Murmuray and the distancing of 25×25 centimeters gave the second highest yield for the same varieties. For Diquet a Bolilising, the distancing of 25 by 25 centimeters for the plant gave the highest yield and a distancing of 20 centimeters apart each way gave the second highest yield.

(3) The plots where the plants were set at 30 centimeters apart each way for Daluson and Murmuray, and 25 centimeters apart each way for Diquet a Bolilising, gave the highest yield and the greatest value of crop after the cost of seed and of planting including seedling separation was deducted.

(4) There was a greater variation in the number of fruiting culms produced per plant where the hills were set farther apart in the field.

(5) The number of fruiting culms per square meter was less as the space between plants was greater.

(6) The number of fruiting culms per unit area is not necessarily an index of higher productivity of a given area.

(7) If rice plants are set at 25 centimeters apart each way, with one plant in a hill, it would give an annual saving of palay seeds to the Filipino farmer of about 1,378,772 cavans (1,034,079 hectoliters); if at 30 centimeters apart each way, 1,455,466 cavans (1,091,584.5 hectoliters).

(8) When the hills are set at 25 or 30 centimeters apart each way, it would mean a saving of labor in transplanting of about 36 per cent or 58 per cent over the 20 by 20 centimeter planting, the average distance of planting rice in the Philippines.

RECOMMENDATIONS

The subject of the rate of seeding and of distances of planting the rice plant is still an open question. Although much remains to be done before any final recommendation can be made, still the results of this work indicate that the wider planting would prove beneficial and practical. It would be to the interest of the Filipino farmer for the Government to verify such results as have been reported in the past, using the different rice growing regions of the Philippines, and at the same time to carry out extensive investigations to determine the best distance and rate of seeding of the best varieties of rice in the Philippines, with respect to production and net profit.

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HOG FEEDING EXPERIMENTS INVOLVING THE USE OF SELF-FEEDERS[1]

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INTRODUCTION

Not more than ten years ago, the practicability of a new method of feeding swine was studied intensively in the United States by Evvard (1). This is the self-feeding system. While this system has given favorable and commendable results from experiments conducted in the United States, it remains to be seen whether the same would hold true in the Philippines where conditions are different. It was with this end in view that the writer conducted the work here reported.

It is important at this point to explain the different features connected with the self-feeding system. A discussion by Evvard (1) in regard to these features follows:

> This system (free-choice system), experimentally demonstrated and developed by the Animal Husbandry Section of the Iowa Experiment Station, is one wherein the animals fed are allowed to have the feeds placed before them in separate containers, so that they may choose or partake of whichever they will. These feeds may be continuously kept before them or they may be allowed periodically. In the former case the system then would be free-choice self-fed, but in the latter free-choice hand-fed. In the former case self-feeders with different feeds within will be placed before the animals, and in the latter open troughs would naturally be used, each containing a separate feed, these to be placed before the animals, which will eat what they will, and after a certain limited time, say an hour or two, or at such times that the animals are satisfied, the troughs may be removed, to be replaced again at a later period. Self-feeding may be practiced with a mixture of feeds; in other words, corn 90 parts and tankage 10 parts, both ground and mixed together, may be fed in an open container. On the other hand, these feeds might be fed free-choice style, both in separate troughs. Let us not, therefore, confuse self-feeding with free-choice feeding; they are two separate and distinct plans.

THE IMPORTANCE OF THE WORK

The importance of this work lies in the fact that while self-feeding has been found to be economical, efficient and practical in the United States, it remains to be seen if it would give the same results under Philippine conditions. Previous work on swine feeding in the College of Agriculture (2) and (3) was based on hand-feeding guided by feeding standards; so far, no data relative to self-feeding in the Philippines has been published.

The self-feeding method being a radical change from the present systems, many questions will naturally arise pertaining to the propriety of its adoption. Thus one may ask: What is a self-feeder? Is it difficult to make one? How much does it cost to build one? Does it save time, labor, feeds, and money? Is it practical in ordinary feeding operations? Will the hogs really balance their own ration? How do self-fed gains compare with hand-fed results? How many

[1] Experiment Station contribution No. 223. Prepared in Department of Animal Husbandry under the direction of Dr. Valente Villegas.

kilograms of feed are required to produce 100-kilogram gain? It was to seek answers to such pertinent questions that this work was undertaken.

PREVIOUS WORK ON THE SUBJECT

At the Iowa Experiment Station (4), an experiment was conducted in 1913 in which hand-feeding was compared with self-feeding, using pigs that were just weaned and which were carried up to 250 pounds in weight. The pigs were started on alfalfa pasture and finished in dry lots. Four lots were used: Lot 1 had ear-corn, hand-fed; Lot 2 had ear-corn plus 7-½ per cent meat meal, also hand-fed; Lot 3 was given ear-corn, hand-fed, and meat meal in the self-feeder; Lot 4 had shelled corn plus meat meal, both self-fed. It was found that the self-fed hogs in Lot 4, getting corn and meat meal, made the largest and cheapest gains. They weighed 250 pounds at the age of eight months and were finished and ready for market 26 days ahead of the rest.

Evvard (4) in his trial with two lots on a quick 30-day experiment, finished 265-pound hogs with corn, fed in one lot in the form of slop and in the other self-fed and dry, the results showing close similarity. In another experiment of similar character, using a different set of hogs, the self-fed hogs showed better results although the difference was small.

Evvard's (4) results on fattening 261-pound old sows on corn showed in one lot which was hand-fed a gain of 2.30 pounds daily, and in the other which was self-fed, a gain of 2.64 pounds daily. The hand-fed lot consumed 436 pounds of corn for every 100 pounds gain and the self-fed one, 417 pounds only. These results show that for mature hogs also, the self-feeder is profitable.

The Iowa Station, cited by Evvard (4), conducted a similar feeding experiment on fattening fairly well-grown yearling pigs weighing around 225 pounds and it was found that the self-fed pigs made 2.05 pounds daily gain or a difference of almost 10 per cent over the hand-fed lot which gained 1.87 pounds a day. The self-fed pigs required less feed and made more profit per head than those hand-fed.

The United States Department of Agriculture (5) conducted a test to compare the relative fattening efficiency of a ration of corn meal, middlings, and tankage when hand-fed and when self-fed, using 18 grade Berkshire pigs, kept in dry lots. The hand-fed lot was fed three times a day giving as much feed as they would consume every feeding and the self-fed pigs had free access to the three feeds given self-choice. The results showed that the self-fed pigs gained much more rapidly by consuming daily rations large in proportion to their live weights than did the hand-fed pigs. The daily rations as represented by live weight were 4.42 and 3.27 per cent, respectively. The self-fed pigs required 410.1 pounds of feeds as compared with 406.4 pounds consumed by the hand-fed lot to make 100 pounds gain in live weight.

The Missouri Agricultural Experiment Station (6), in 1914, conducted a test comparing hand-feeding and self-feeding, using a mixture of corn 10 parts and tankage 1 part. The results showed a very slight difference in favor of hand-feeding. The hand-fed pigs made an average daily gain of 1.98 pounds as compared with 1.97 pounds gained by pigs that were self-fed. But it must be noted that the self-fed lot consumed only 7.85 pounds of feed a day while those which were hand-fed consumed 8.28 pounds. The amount of feed required to produce

1 pound of gain in the case of self-fed hogs, was 4.0 pounds and 4.18 pounds in the case of the hand-fed lot.

Another experiment was conducted in the Missouri Station, similar to the preceding one, except that shorts or middlings were added with both lots, and the hand-fed lot was given corn 8 parts, shorts 2 parts and tankage 1 part, and the same feeds were given to the self-fed lot by the free choice system. In this experiment, the self-fed hogs gained more rapidly than the hand-fed individuals. The self-fed hogs consumed an average of 7.08 pounds of feed and made an average gain of 1.69 pounds per head daily as compared with 6.07 pounds consumption and 1.51 pounds gain per head daily by the hand-fed lot.

To determine the relative efficiency of the feeding standards and the ability of pigs to make economic gains according to their physiological needs, if the proper feeds are placed before them, Evvard (7) conducted dry lot experiments on the following plan:

Group I.—Fed according to the free-choice system.

Group V.—Fed according to the Dietrich system—water limited according to standard.

Group VI.—Fed according to the Kellner system.

Group VII.—Fed according to the Wolff-Lehmann system.

Group I was fed with different feeds on the free-choice system and the rest were hand-fed twice a day with mixed feeds compounded according to the different standards used.

The following results were obtained:

Weights and gains of the pigs the first 150 days.

Group No.	Final weight.	Average daily gain.
	lbs.	*lbs.*
I. (Free-choice system)..	223.2	1.21
V. (Dietrich system)	187.6	.97
VI. (Kellner system).....	174.8	.89
VII. (Wolff-Lehmann system).....	144.8	.69

From these results, it is evident that the free-choice, self-fed pigs gave the most rapid gain and that the older the standard the less is its efficiency.

The same experiment was carried further in order to find out the time and feed required to reach 225 pounds of weight. After six months, the lots were all fed by the free-choice system and the following results were secured:

Record up to 225 pounds weight and feed required for 100 pounds gain.

Group No.	No. of days taken.	Corn.	Wheat middlings.	Meat meal tankage.	Total.
I	229	356	45	43	444
V	268	403	45	45	493
VI	271	353	55	57	465
VII	294	380	46	42	468

When the pigs were self-fed by the self-choice style up to 225 pounds, Lot 1, or the free-choice lot, required the least number of days (229) to reach the desired weight. This period was 39 days shorter than that of the lot fed according to Dietrich's standard; and 65 days shorter than the lot fed according to the Wolff-Lehmann standard.

Feeding up to 300 pounds weight gave a different story. The method of feeding which is best for 200-to-225 pound pigs is not necessarily the best for making 300-to-400-pound individuals. The number of days required in Group 1, or the self-fed, self-choice lot, to reach 300 pounds was 323; 342 in the case of the Dietrich standard lot or 19 days longer; and 329 with the Kellner standard group or 6 days longer; and 346 in the case of pigs fed according to the Wolff-Lehmann standard or 23 days longer. With regard to the amount of feed consumed for every 100 pounds of gain, the results were in favor of the Kellner and Wolff-Lehmann standards.

Ashbrok and Gongwer (5) of the United States Department of Agriculture made a compilation from different experiment stations in the United States of the results obtained with the self-feeder, obtaining the following data:

Average results with self-feeder at Experiment Stations.

Number of pigs.	Methods of feeding.	Average days fed.	Average daily gain per head.	Average daily feed per head.	Average amount of feed per 100-lb gain.
			lbs.	*lbs.*	*lbs.*
262	Hand-fed	82.2	1.23	5.47	445
323	Self-fed	68.5	1.92	8.00	417

The above results show clearly that more rapid gains are obtained with the self-feeder than with the best hand-feeding method.

OBJECTS

This work was conducted with the following objects in view:

1. To determine the relative efficiency of sweet potato, cowpea, and mungo pasture, with corn, rice bran, and copra meal as concentrates, self-fed, self-choice.

2. To compare the relative value of corn and copra meal, and rice bran and copra meal, all self-fed, self-choice, with sweet potato in both as pasture.

3. To find out the relative merits of self-feeding and hand-feeding, using corn, copra meal, and rice bran fed in the self-fed lot and fed by the self-choice style, and the same concentrates in the hand-fed lot, fed according to the Modified Wolff-Lehmann standard.

4. To determine whether the addition of dried shrimps as a source of animal protein in the feed will give any advantage in fattening swine, using sweet potato as pasture.

Rations fed.

EXPERIMENT I:	
Lot 1	Corn, rice bran, and copra meal Self-fed, self-choice—sweet potato pasture
Lot 2	Corn, rice bran, and copra meal Self-fed, self-choice—cowpea pasture
Lot 3	Corn, rice bran, and copra meal Self-fed, self-choice—mungo pasture
EXPERIMENT II:	
Lot 4	Corn and copra meal Self-fed, self-choice—sweet potato pasture
Lot 5	Rice bran and copra meal Self-fed, self-choice—sweet potato pasture
EXPERIMENT III:	
Lot 6	Corn, 1 part, copra meal, 2 parts, rice bran, 3 parts (by weight) Hand-fed—sweet potato pasture
EXPERIMENT IV:	
Lot 7	Corn, copra meal, and rice bran plus 1/10 shrimps (by weight). Self-fed, self-choice—sweet potato pasture.
Lot 8	Corn and shrimps Self-fed, self-choice—sweet potato pasture.

MATERIALS AND METHOD

Pigs used.—The pigs used in this experiment, with the exception of three bought in Calamba, Laguna, were all Berkshire-Jalajala grades varying in the proportion of Berkshire blood from 3/8 to 7/8. They were raised by the Department of Animal Husbandry and received the same treatment and feed from birth. The conformation of the three pigs bought in the Calamba market showed infusion of Berkshire blood. In allotting the pigs in each experiment the proportion of such factors as age, weight, sex, breeding, and thrift was made as uniform as possible.

Shelter.—With the exception of Lots 1 and 2, the pigs had no shelter other than the trees in the lots. Almost all of the lots, except the two mentioned above, had enough shade trees and shrubbery to give sufficient shelter. Lots 1 and 2, being in the open pasture, were provided with a shed of coconut leaves supported on an improvised framework.

Weighing.—The pigs were weighed individually for three consecutive days at the beginning and at the end of the experiment. The averages of these weights were taken as the initial and final weights of the animals. Every tenth day between 7 and 10 o'clock in the morning, individual weights were taken throughout the experiment. Care was taken to have the condition at weighing time as nearly normal as possible. The pigs were weighed by driving them one by one in a constructed crate over the scale.

Watering.—A wooden or bamboo trough was provided in each lot for watering the pigs. It was placed in a shady place a short distance from the self-feeder so that the pigs could have easy access to it. Clean water was run into the trough three or four times a day, providing sufficient water at all times.

Plan of feeding.—All lots except the hand-fed lot were each provided with a self-feeder. The self-feeder was divided into three chambers where the individual feeds were placed. A known quantity of individual feeds was provided at all times so that the pigs could select the feed they wanted at any time. The amount of individual feeds consumed every day was determined as well as the consumption from the beginning to the end of the experiment.

The hand-fed lot was fed twice a day, morning and afternoon.

All the experiments began with the evening feed of the first day and closed with the morning feed of the last day of the experiment.

Feeds used.—Concentrates: The corn used was a Native Yellow Flint variety raised by the Agronomy and Animal Husbandry Departments. The rice bran was bought from a dealer in Santo Rosa, Laguna. This bran was fairly free from rice hulls and may be considered as grade B rice bran. The copra meal was bought from Derham Brothers Company, Manila, and was in pressed slabs containing about 14 per cent of moisture. The shrimps were caught in Laguna de Bay by a fisherman who was employed for this purpose. The shrimps were brought to the College either fresh or sun-dried. Fresh shrimps were dried in the sun.

The pigs were given salt and corn cob charcoal, mixed together, three times a week.

Prices of feeds.—The prices of corn and copra meal are based on the report of the Bureau of Commerce and Industry (8) dated December 31, 1922. According to this report, the price of one cavan of shelled corn weighing 57.5 kilograms was from ₱4.00 to ₱4.30; and copra meal from ₱38.00 to ₱40.00 a ton (1000 kilograms). The prices of rice bran and shrimps are not given in this report. The price of one cavan of rice bran from dealers in the different towns of Laguna was from ₱1.20 to ₱1.70 a cavan, weighing on an average 29.475 kilograms. The price of shrimps as quoted by fishermen during times of plentiful supply is from ₱1.50 to ₱2.50 a cavan weighing 9 kilograms.

The self-feeder.—The self-feeders used in these experiments were made by the Service Division of the College of Agriculture, modified from the plan shown in Figure 8 of Farmer's Bulletin No. 906. Each self-feeder is 97 cm. high. 90 cm. wide and 46 cm. thick. The hopper is divided into three equal compartments into each of which one kind of feed was placed. Each compartment is provided with its own slide and regulator to gauge the outflow of feed into the trough. Each compartment is so made as to hold about 15 kg. of feed. The trough is separated into three chambers corresponding to the compartments of the hopper so as to prevent the mixing of feeds and overcrowding of the pigs during feeding time. A cover projecting about 15 cm. on all sides of the self-feeder was provided to protect the grain from the effects of bad weather. This cover is attached to the body of the self-feeder by means of hinges so that it can be opened or closed without difficulty.

Six wooden self-feeders equal in size and of the construction described above were used in these experiments. Each self-feeder was large enough to accommodate three pigs at a time. The cost of lumber and other materials and labor in making a self-feeder are as follows:

Lumber used, 50 bd. ft. at 0.10	₱5.00
Nails	.35
2 strap hinges at ₱0.35	.70
Labor	7.50
Total	₱13.55

The total cost of 6 self-feeders was, therefore, ₱81.30.

THE EXPERIMENTS

EXPERIMENT I

Experiment I was conducted for the purpose of comparing the relative efficiency of sweet potato, cowpea, and mungo pasture, with corn, rice bran, and copra meal as concentrates—self-fed, self-choice.

The experiment was begun on November 13, 1922, and closed on January 22, 1923, covering a period of 70 days. The plan in all of the experiments reported in this paper, was to carry the work until the pigs in the lot reached approximately 225 pounds, or 100 kilograms of weight each, but due to lack of facilities, especially feeds, the duration of the experiment was shortened to 70 days. Twelve pigs of mixed sex and blood, having an average weight of 46.46 kg. were used. They were divided into three uniform lots. Lot 1, having 188.6 kg. as the total weight of pigs was turned out on sweet potato pasture and designated as sweet potato lot. Lot 2 with a total weight of 189.3 kg. was placed in a cowpea pasture and designated as the cowpea lot. Lot 3, of 189.7 kg. weight, was assigned to the mungo pasture and known as the mungo lot. All the lots were given the same kind of concentrates in a self-feeder; namely, corn, rice bran and copra meal, and fed free-choice. The animals were all in medium flesh at the beginning of the experiment.

Sweet potato pasture.—The sweet potato pasture of Lot 1 was a second growth pasture. Its area was approximately one-fourth of a hectare. Hogs were pastured on this lot in May, 1922. It was observed that during the first few days the pigs consumed only a little of the grain as they were more inclined to forage on the succulent young stems, leaves, and tubers. The pigs ate the tender tips first, then the younger leaves when no more tips could be found. It was found also that during the first few days the pigs did considerable rooting, especially in the morning and afternoon, and ate plenty of tubers. But toward the latter part of the experiment, they did not root very much. They were seen most of the time either eating from the self-feeder or lying down under the shade. The same observations hold true with all the lots, except Lot 4 which will be discussed later.

Cowpea pasture.—The cowpea pasture used in this experiment, had an area of about one-fourth of a hectare, and was planted on September 15, 1922. The seeds were planted in rows about a meter apart at a distance of about 75 centimeters in the row. When the hogs were turned to pasture on this lot on November 13, 1922, the plants were in full bloom. The majority of the pods were about in the middle stage of formation. The pigs ate the pods first and then the leaves. They ate also the tender stems when no more pods could be found. In about 30 days almost all of the pods were consumed. At this time the pigs were observed to root at times but more often they were seen lying near the self-feeder, so as to feed now and then on the grains contained in it. It was observed that although the lot was heavily pastured many of the plants survived and later on produced pods. In spite of this, the pigs were seldom seen on the pasture during the latter part of the experiment. After the experiment was over most of the plants that were left were still flowering and developing pods. These observations show that cowpea is a productive and good pasture crop for swine.

Mungo pasture.—The pastures used in Lot III were planted in two separate lots. One was planted on September 16, 1922, and the other about two

weeks later. During podding, the first pasture became infected with leaf spot of mungo (*Cercospora cruenta* Sacc). When the pigs were turned into it on November 13, 1922, the entire field was affected. The majority of the pods were at the middle stage of development. The pigs ate the pods, tender stems, and leaves. Most of the pods were consumed during the first two days of the experiment and the feeds in the self-feeder remained practically untouched. Probably due more to the disease than to anything else, at the end of 10 days no green leaves could be seen in the field. Almost all the plants were dead and the whole field, having an area of 1300 square meters, was ruined.

On November 23, 1922, the pigs were transferred to the second enclosure having an area of about one-eighth of a hectare. The mungo plants in this pasture were still blooming but the majority of the pods were halfway formed. The pigs ate the pods first and then the tips and matured leaves. It was found that mungo could not stand heavy pasturage. The stems are so brittle that they break easily upon being trampled by the animals, and then the plant dies. Besides, while the pods were being eaten many of the plants were pulled up and died. After about 15 days pasturing, the appearance of the leaf spot was noticed and in about three weeks the whole field of mungo disappeared, owing mainly to the pigs but partly to the disease. From this time (December 31, 1922) until the end of the experiment, the animals utilized for pasture the little quantity of mixed grasses growing in the lot, mostly *Paspalum conjugatum.*

EXPERIMENT II

Experiment II was conducted for the purpose of comparing the relative value of corn and copra meal, and rice bran and copra meal, all self-fed, self-choice, with sweet potato in both as pasture. Eight pigs, breeding and condition similar to those used in Experiment I, were used in this test. They were divided into two uniform lots of four pigs each. One lot of a total weight of 187.0 kg. was turned to sweet potato pasture and fed corn and copra meal. This lot was designated as Lot IV, or corn lot. The other lot of a total weight of 185.9 kg. was placed in another sweet potato pasture and fed rice bran and copra meal. This lot was designated as Lot V, or rice bran lot.

Pasture used.—The two pastures of Lots IV and V occupy 1496.5 and 1095.0 square meters of surface, respectively. The growth of the sweet potato in both lots was almost the same, the soil condition being similar and the plantings being made on the same date. They were planted on July 5, 1922, and the pigs were turned on the pasture on October 9, 1923

During the first few days, the pigs in both lots foraged very heavily and only a little amount of the concentrates was consumed. After about ten days, the pigs in Lot IV, or corn lot, gradually showed disinclination to forage and later on they were seldom seen in the pasture. They stayed most of the time in the shade and when hungry fed from the self-feeder and the consumption of the grain was very rapid. In the case of Lot V, or rice bran lot, there was an evident increase in appetite of the animals for forage. By November 13, 1922, pasture for Lot V was almost exhausted, little was left but the older and fibrous stems. It became necessary to transfer the pigs to another sweet potato pasture having an approximate area of 888 square meters and in good condition. After ten days in this pasture the pigs showed a gradually decreasing appetite for forage seldom touch-

ing the sweet potato, preferring to forage on mixed grasses whenever they had an opportunity, especially on weighing days when they were driven to the balance outside of the pasture. At the close of the experiment, there was still plenty of sweet potato forage left in the pasture. Lot IV, or the corn fed pigs, which consumed less of the sweet potato forage in the earlier part of the experiment, rooted heavily during the latter part, so that at the end of the experiment there was hardly any of the forage left in the lot.

EXPERIMENT III

This experiment was conducted to determine the relative merits of self-feeding and hand-feeding. In a previous experiment the hand-fed pigs were in a lot that had some ipil-ipil (*Leucaena glauca*) trees growing. They may have eaten of the fallen seeds from those trees so that an error crept in the experiment. This lot was therefore repeated, using pigs of similar age and breeding as the self-fed lot, as may be seen from Table X.

In this lot four pigs of a total weight of 186.9 kg. were used. They were turned to a sweet potato pasture having an area of about one-fourth of a hectare, and a feed mixture of corn, one part; copra meal, two parts; and rice bran, three parts, by weight, was hand-fed twice a day. The animals were given as much feed as they would consume.

EXPERIMENT IV

Knowing the splendid results obtained in the United States when corn and tankage are self-fed, self-choice, the writer started Experiment IV, in which, however, dried shrimps were used instead of tankage. Tankage being a source of animal protein, shrimps were therefore taken to fulfill the same purpose.

In this experiment, two lots of four pigs each were used. Owing to lack of sufficient number of animals in the College herd, the writer was obliged to purchase three pigs in Calamba, Laguna. These pigs are described under "Pigs used" in this paper. The rest of the pigs in the experiment were of similar breeding to those used in the previous experiments. The pigs that were bought were quarantined the first day and subjected to preliminary feeding as was the case with the others.

The eight pigs were divided into two uniform groups. One group or Lot VII having a total initial weight of 194.1 kg. was given corn, rice bran mixed with one-tenth, by weight, of dried shrimps, and copra meal; were self-fed, self-choice. The other group with a total initial weight of 194.2 kg. was fed shrimps and corn; were self-fed, self-choice. Both of these lots were pastured in sweet potato pasture with an area of 2175 square meters each. The test was carried out for a period of 70 days as with the other experiments.

DISCUSSION OF RESULTS

EXPERIMENT I

The computed results of Experiment I are given in Table II. This table shows that the pigs on sweet potato pasture made 1.8 kg. total gain over the cowpea lot and 48.8 kg. over the mungo pasture, while the cowpea lot had an advantage of 47.0 kg. over the mungo lot. With regard to the feed requirements per 100-kilogram gain, the cowpea lot showed the best results, having consumed the least feed per unit of gain and also gave the lowest cost of production. The cowpea lot required 435.0 kg. of grain to produce 100 kg. of gain, as compared

with 452.0 kg. for the sweet potato lot and 730.4 kg. for the mungo lot. Throughout the experiment the weights of the animals in both the cowpea and sweet potato lots ran almost parallel.

The three lots of pigs in this experiment were treated in the same way and given the same kind of concentrates, the difference being only in the pasture, so it is evident that any difference in condition, health, thrift, weight, etc. of the animals must necessarily be due to the pastures.

Inasmuch as the differences in the results of the experiment are due to the individual pastures tested, Table I showing the analysis of the pastures is submitted. From Table I, it is evident that sweet potato tubers excel in fattening nutrients, such as the carbohydrates. The percentage of constituents of the tips is similar to that of cowpeas or mungo pods. The mungo pods are higher in either extract. The table shows good analysis of mungo pods but the inferior results obtained from the mungo pasture is largely due to the weak stand of plants resulting from the attack of leaf spot, small production, and inability to withstand pasturage, all tending towards a meagre productive ability of this pasture crop. Cowpea pods, according to Table I, contain appreciable amounts of nutrients and the fact that pigs relished the tender stems of this crop adds to its high feeding value. Hence, the favorable results obtained with this pasture crop.

Dodson of the Louisiana Station cited by Henry and Morrison (9) recommends sweet potato as the best root crop for pigs for fall and early winter grazing on the cut-over pine lands of the South. According to this authority, an acre of sweet potato in 60 days can take care of 8 to 10 yearling pigs when given a limited concentrate in addition. Duggar of the Alabama Station, cited by Henry and Morrison (9), found that by allowing pigs to harvest sweet potato at will 100 pounds of gain were secured upon the addition of 313 pounds of grain, thereby saving about 200 pounds grain for each 100 pounds increase while fattening. The different points in favor of sweet potato as a premier pasture crop for hogs under Philippine conditions are the following:

1. Sweet potato is easy to raise.
2. It stands heavy pasturage.
3. A field of this crop may be stocked two or three times after periods of rest without replanting.
4. When not pastured too heavily and under favorable climatic conditions, a new pasture may be had within one and a half or two months after the last stocking.
5. If not overstocked, the old tubers left in the field will grow when the field is plowed, producing a new crop without planting.
6. The tubers contain over 35 per cent carbohydrates.
7. The yield is heavy, both in tubers and forage.

The superior merits of cowpea for pasture lie principally in its high feeding value, high production, adaptability to a variety of conditions and ability to withstand heavy stocking. As to production, Constantino (10) found in his experiment that the average yield in the College of Agriculture is 5003.14 kilograms a hectare, the growing period being from 61 to 87 days from planting to maturity. Constantino claims that from August to December is the best growing season at this College.

EXPERIMENT II

Table III is presented to show the results of Experiment II.

From this table, it is clear that the pigs receiving corn and copra meal, made a total gain of 135.6 kg. and those receiving rice bran and copra meal, 105.80 kg. or a difference of 29.6 kg. in favor of corn. The rate of gain per day by the individual pigs in Lot IV, is on the average, 0.480 kg. as compared to 0.378 kg. in Lot V, showing a difference of 0.102 kg. The amount of feed required to produce 1 kg. of gain both lots, shows but a slight difference. But it costs more to produce 1 kg. of gain in the corn lot than in the rice bran lot due to the higher price of corn.

That corn made a better showing, may be attributed to the fact that corn is more carbonaceous than rice bran. Corn, then, is more efficient than rice bran for fattening market pigs when supplemented with copra meal and sweet potato is used as pasture. This result is contrary to results obtained by Bautista (3). Bautista found that rice bran is a more efficient feed than shelled corn, but in his work the animals were hand-fed on a dry lot so that the two experiments can not be directly compared. Of interest in this experiment is the behavior of the pigs in Lot V which did considerably more rooting than those of Lot IV. The reason for this behavior is not known.

EXPERIMENT III

The results of Experiment III are presented in Table IV.

According to Table IV, it appears that pigs fed with corn, rice bran, and copra meal—self-fed, self-choice—with sweet potato as pasture made a total gain of 130.2 kg. While pigs receiving the same kind of grains but in the proportion of 1 part corn, 2 parts copra meal, and 3 parts rice bran, by weight, hand-fed, on the same pasture, made a total gain of 79.5 kg. or a difference of 50.7 kg. in favor of the former. The self-fed lot made an average gain per head of 0.465 kg. and the hand-fed lot an average of 0.284 kg. The amount of feed required to produce 1 kg. gain in the case of self-fed hogs was 4.53 kg. as compared with 4.25 kg. in the hand-fed lot, costing ₱0.286 in the former and ₱0.201 in the latter, or a difference of ₱0.085 in favor of the hand-fed lot.

However, although in the hand-fed lot it cost ₱0.085 less to produce 1 kg. of gain than in the self-fed lot, in the self-fed lot a gain of 50.7 kg. more than in the hand-fed lot was obtained in the same length of time. Therefore, from the standpoint of gain, Lot I had the advantage and the method is more desirable where fast turn-over of capital in swine production is the aim.

EXPERIMENT IV

The results of Experiment IV are given in Table V.

It is clearly shown in this table that there is no marked difference in the results of the three lots compared. Lot 7 receiving corn, copra meal, and rice bran with one-tenth shrimps added to rice bran, by weight, gained 128.0 kg.; Lot 8 receiving shrimps and corn gained 129.3 kg.; and Lot 1 which received corn, rice bran, and copra meal, but no shrimps, gained 130.2 kg.

As to feed consumption, Lot 1 consumed 589.4 kg. or 117.5 kg. more than Lot 8 and 57.3 kg. more than Lot 7. In regard to the amount of feed necessary to produce one kg. of gain, Lot 8 required the least, that is, 3.65 kg. of feed was required to make one kg. of gain in Lot 8; 4.52 kg. in Lot 1; and 4.15 kg. in Lot 7.

In the cost of feed to produce one kg. of gain, Lot 8 gives the highest figure, or ₱0.40 as compared with ₱0.28 and ₱0.27 in Lot 1 and Lot 7, respectively.

It is evident from the figures given above that a ration of copra meal and rice bran with one-tenth shrimps added to rice bran, by weight, and a ration of shrimps and corn in both cases—self-fed, self-choice—with sweet potato as pasture for both, has no advantage over a ration of copra meal, rice bran, and corn—self-fed, self-choice—on the same pasture.

SUMMARY

EXPERIMENT I

In this experiment, the relative efficiency of sweet potato and cowpea as pasture crops for fattening swine with corn, rice bran, and copra meal as basal ration, —self-fed, self-choice—indicates that the difference between the two is slight. The results ran almost parallel, although sweet potato showed a little advantage in the rate of gain. In the cost of production per kilogram of gain the results were slightly in favor of cowpea. The mungo pasture did not show up to any advantage at all. The pigs in this lot consumed relatively great amounts of feed and produced little gain. Furthermore, the mungo pasture could not stand heavy grazing and the plants diminished in quantity due to destruction caused by disease. Maturity was reached early, but the plant died early.

Points in favor of sweet potato and cowpea as pasture crops are the following: Both sweet potato and cowpea can be raised readily; both withstand heavy pasturage and produce heavily, and finally their feeding value is high.

EXPERIMENT II

In this experiment the pigs receiving corn and copra meal, or Lot IV gained more than the pigs receiving rice bran and copra meal, or Lot V, or a total gain of 135 kg. in the case of Lot IV, and 105 kg. in Lot V.

With regard to the amount of feed required to produce one kg. of gain, the difference is small, but the feed cost of Lot V being cheaper than that of Lot IV, it follows that it costs less to produce 1 kg. of gain in Lot V. However, from the standpoint of gains, the rapid fattening in Lot IV has its advantage and therefore may show up better where fast turn-over of capital in swine production is desired.

EXPERIMENT III

Self-fed hogs gained more rapidly, making 130.2 kg. as compared with 79.5 kg. in the case of the hand-fed lot. As to the amount of feed consumed per kilogram of gain the hand-fed lot required just a little less feed. But since the self-fed lot gained considerably more than the hand-fed lot, or a difference of 50.7 kg., therefore, as a business enterprise in which rapid turn-over of capital is the more desirable, the self-fed, self-choice lot has the advantage.

EXPERIMENT IV

The results of this experiment show that shrimps as a source of animal protein effected great saving of grain necessary to make 100 kilograms of gain where this feed is used with corn, while a lesser amount of grain is saved when shrimps form one-tenth of the mixture with rice bran with corn and copra meal as other grains in the self-feeder. The cost of grain to make 100 kilograms of gain is necessarily higher with shrimps and corn alone as feeds, due to relatively higher cost per unit amount of shrimps, but the including of one-tenth shrimps in the feed reduced the cost of gains a little lower than that in which no animal protein was used.

CONCLUSIONS

The following outstanding points are here given as the results of this work:

1. Using sweet potato, cowpea, and mungo as pasture for fattening market pigs receiving a ration of corn, rice bran, and copra meal—self-fed, self-choice—the sweet potato and the cowpea proved to be the better pasture crops, being about equal.

2. Comparing corn with rice bran as basal feeds for fattening market pigs, with copra meal as supplement, and sweet potato for pasture in both, the corn lot gave the better result.

3. Comparing corn, rice bran, and copra meal—self-fed, self-choice—with sweet potato as pasture, with the same ration fed according to the modified Wolff-Lehmann standard, hand-fed, and with the same pasture, the results obtained were in favor the self-fed lot.

4. A ration of corn, copra meal, and rice bran, with one-tenth dried shrimps added to rice bran by weight, using sweet potato as pasture, for fattening market pigs—self-fed, self-choice—has no advantage over the same concentrates and pasture containing no animal protein in the form of shrimps.

5. A ration consisting of corn and dried shrimps—self-fed, self-choice—using sweet potato as pasture gave no better results for fattening market pigs than a ration of corn, copra meal, and rice bran without shrimps—self-fed, self-choice—on the same pasture.

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TABLE I.—*Percentage composition of feeds.*

	Moisture.	Ash.	Protein (N.×6.25)	Crude fiber.	Carbohydrates.	Fat. (ether extract)
Concentrates:						
Corn	14.34	1.58	8.43	10.92	60.58	4.15
Copra meal	12.83	7.26	17.50	15.73	40.91	5.77
Rice bran	13.81	15.48	11.56	1.42	49.32	8.41
Shrimps (dried)	14.55	19.73	55.61	4.24	3.26	2.61
Fresh green roughage:						
Sweet potato tubers	71.51	1.07	0.92	0.78	25.32	0.40
Sweet potato tips	85.42	1.70	2.76	3.50	6.48	0.14
Cowpea pods (medium age)	84.55	.87	2.48	3.48	8.40	0.42
Mungo pods (medium age)	82.01	1.07	2.96	3.63	9.14	1.19

TABLE II.—*Computed results of EXPERIMENT I.*

	LOT 1 *Self-feeder, Self-choice.* Corn, rice bran, copra meal, sweet potato pasture.	LOT 2 *Self-feeder, self-choice.* Corn, rice bran, copra meal, cowpea pasture.	LOT 3 *Self-feeder, self-choice.* Corn, rice bran, copra meal, mungo pasture.
Number of pigs	4	4	4
Duration of experiment	70 days	70 days	70 days
Total initial weight	188.6 kg.	188.6 kg.	189.7 kg.
Average initial weight	47.15 kg.	46.59 kg.	47.42 kg.
Total final weight	318.8 kg.	317.0 kg.	271.1 kg.
Average final weight	79.5 kg.	79.25 kg.	67.775 kg.
Total gain	130.2 kg.	128.4 kg.	81.4 kg.
Average daily gain per head	.465 kg.	.458 kg.	.291 kg.
Grain consumed:			
Corn	403.1 kg.	414.3 kg.	507.5 kg.
Rice bran	158.2 kg.	119.5 kg.	78.0 kg.
Copra meal	28.1 kg.	26.3 kg.	9.1 kg.
Total grain feed consumed	589.4 kg.	560.1 kg.	594.6 kg.
Cost of grain consumed:			
Corn	₱28.217	₱29.0	₱35.525
Rice bran	7.910	5.975	3.90
Copra meal	1.124	1.052	.36
Total cost of grain consumed	37.251	36.027	39.785
Average daily grain feed per pig	2.105 kg.	2.0 kg.	2.123 kg.
Grain feed consumed per kilo gain	4.53 kg.	4.36 kg.	7.304 kg.
Grain consumed per 100-kilo gain	453.0 kg.	436.2 kg.	730.4 kg.
Cost of grain per kilo gain	₱.286	₱.2805	₱.4886
Cost of feed per 100-kilo gain	₱28.61	₱28.05	₱48.86

TABLE III.—*Computed results of EXPERIMENT II.*

	LOT 4 *Self-feeder, self-choice.* Corn, copra meal, sweet potato pasture	LOT 5 *Self-feeder, self-choice.* Rice bran, copra meal, sweet potato pasture
Number of pigs	4	4
Duration of experiment	70 days	70 days
Total initial weight	187.0 kg.	186.9 kg.
Average initial weight	46.75 kg.	46.72 kg.
Total final weight	322.60 kg.	292.70 kg.
Average final weight	80.65 kg.	73.17 kg.
Total gain	135.60 kg.	105.80 kg.
Average daily gain per head	0.484 kg.	0.378 kg.
Grain consumed:		
Corn	477.00 kg.	0.00
Rice bran	0.00	306.16 kg.
Copra meal	22.54 kg.	20.94 kg.
Total grain feed consumed	499.54 kg.	327.10 kg.
Cost of grain consumed:		
Corn	₱33.39	0.00
Rice bran	0.00	₱15.30
Copra meal	₱ .902	₱0.838
Total cost of grain consumed	₱34.292	₱16.138
Average daily grain per pig	1.784 kg.	1.168 kg.
Grain consumed per kilo gain	3.683 kg.	3.091 kg.
Grain consumed per 100-kilo gain	368.3 kg.	309.1 kg.
Cost of grain per kilo gain	₱0.252	₱ .156
Cost of grain per 100-kilo gain	₱25.20	₱15.63

TABLE IV.—*Computed results of EXPERIMENT III.*

	LOT 1 *Self-feeder, self-choice.* Corn, rice bran, copra meal.	LOT 6 *Hand-fed.* Corn .... 10 parts by weight. Rice bran 3 „ „ „ Copra meal 2 „ „ „
Number of pigs	4	4
Duration of experiment	70 days	70 days
Total initial weight	188.6 kg.	186.9 kg.
Average initial weight	47.15 kg.	46.72 kg.
Total final weight	318.80 kg.	266.4 kg.
Average final weight	79.5 kg.	66.6 kg.
Total gain	130.2 kg.	79.5 kg.
Average daily gain per head	0.465 kg.	.284 kg.
Grain consumed:		
Corn	403.1 kg.	53.33 kg.
Rice bran	158.2 kg.	106.67 kg.
Copra meal	28.1 kg.	160.0 kg.
Total grain feed consumed	589.4 kg.	320.0 kg.
Cost of grain consumed:		
Corn	₱28.217	₱3.73
Rice bran	₱ 7.910	₱ 5.33
Corn meal	₱ 1.124	₱ 6.40
Total cost of grain consumed	₱37.251	₱15.46
Average daily grain per pig	2.105 kg.	1.14 kg.
Grain feed consumed per kilo gain	4.53 kg.	4.00 kg.
Grain consumed per 100-kilo gain	453.0 kg.	400.20 kg.
Cost of grain feed per kilo gain	₱ 0.286	₱ .194
Cost of feed per 100-kilo gain	₱28.61	₱19.44

TABLE V.—*Computed results of EXPERIMENT IV.*

	LOT 7 *Self-feeder, self-choice.* Corn, rice bran, +1/10 shrimps, copra meal, sweet potato pasture.	LOT 8 *Self-feeder, self-choice.* Corn, shrimps, sweet potato pasture.	LOT 1 *Self-feeder, self-choice.* Corn, rice bran, copra meal, sweet potato pasture.
Number of pigs	4	4	4
Duration of Experiment	70 days	70 days	70 days
Total initial weight	194.1 kg.	194.20 kg.	188.6 kg.
Average initial weight	48.52 kg.	48.55 kg.	47.15 kg.
Total final weight	322.10 kg.	323.50 kg.	318.20 kg.
Average final weight	80.52 kg.	80.87 kg.	79.70 kg.
Total gain	128.00 kg.	129.30 kg.	130.20 kg.
Average daily gain per head	.457 kg.	.462 kg.	.465 kg.
Grain consumed:			
Corn	279.40 kg.	330.5 kg.	403.10 kg.
Rice bran	220.95 kg.	——	158.20 kg.
Copra meal	7.20 kg.	——	28.10 kg.
Shrimps	24.55 kg.	141.4 kg.	——
Total grain feed consumed	532.10 kg.	471.9 kg.	589.4 kg.
Cost of grain consumed:			
Corn	₱19.55	₱23.14	₱28.217
Rice bran	11.05	——	7.91
Copra meal	.28	——	1.124
Shrimps	4.91	28.28	——
Total cost of grain consumed	35.79	51.42	36.251
Grain consumed per kilo grain	4.15 kg.	3.65 kg.	4.52 kg.
Grain consumed per 100 kilo grain	415.0 kg.	365.70 kg.	452.0 kg.
Cost of grain per kilo grain	₱.28	₱.40	₱.286
Cost of grain per 100 kilo grain	27.96	40.0	28.61

BREEDING ORNAMENTAL HIBISCUS II: ARTIFICIAL AND NATURAL SELECTION FOR DWARF, MEDIUM AND TALL SEEDLINGS[1]

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WITH ONE PLATE

A preliminary report was made in the first paper[2] (1923) on the ornamental Hibiscus seedlings that were raised in this College about three years ago. These were seedlings of different varieties of *Hibiscus rosa-sinensis*. No mention was made in that report about dwarf, medium, and tall seedlings, except that these could be grouped as such, and that the dwarfs were believed to be well adapted for pot ornamentals; something new in the Philippines in ornamental hibiscus growing. In the present paper, the authors attempt to bring out the adaptability of the dwarf and medium seedlings for pot cultures and the practical relation of the tall and dwarf types to natural and artificial selection.

By dwarf seedlings, in this article, is meant those seedlings which grew in height so slowly that when at the age of about nine months they began to flower, they were hardly two decimeters tall, while the other types ranged from about a half to one meter in height. In general, the branches in the dwarf forms are produced very close to the ground, the attachment to the stem being scarcely two centimeters above. In the taller varieties the branches are attached to the stem at about one-half meter or more above the ground. Moreover, the leaves of the dwarf varieties are smaller than on the taller seedlings. In size of flowers there is no difference, that is, the size of the flower does not appear to be correlated with the height of the variety. At the age of three years, the dwarf seedlings were about one-half meter or less in height, while the "tall" ones were four times as high and sometimes more. The medium seedlings ranged in height between the dwarf and the tall.

Even very early in the life of the seedlings, when they are five centimeters or less in height, it is possible to distinguish some of the dwarf forms from the taller groups.

NATURAL SELECTION

When the three types of seedlings were grown together in a plot, the tall individuals, as would be expected, were observed to have the best chance of surviving, while the dwarfs had the least. At the end of three years, most of the dwarf and some of the medium individuals had died, a natural elimination. It should be mentioned here that this observation was made on plants grown 35 centimeters apart each way. The death of the plants was apparently not due to any disease or pest attack on either the roots or the stems and leaves. Those that died just showed lack of vigor at the beginning, then gradual de-

[1] Experiment Station contribution No. 224.

[2] Mendiola, Nemesio B., and Capinpin, Jose M. Breeding Ornamental Hibiscus. The Philippine Agriculturist 11: 127-230.

crease in number of leaves, until finally no life was left. The medium plants which died showed the same symptoms. Not one of the tall seedlings died. The authors are inclined to believe that natural elimination in this case was a matter of lack of adaptation, the dwarf seedlings not being adapted to conditions in which the taller plants thrived to a fair degree. When some of the dwarf hibiscus which appeared almost dead were removed from the plot and placed in 9-inch pots, they subsequently showed even more than their original vigor and flowered constantly, whereas in the plot, they would flower only very occasionally in the period of their decline. The tall hibiscus flowered continuously without being removed from the field of the struggle for existence and such varieties as were adapted to natural seed production produced pods and seed.

Under proper conditions of moisture and temperature the seeds which drop from the ripened pods to the ground germinate and produce new seedlings. This fact indicates that even if some of the dwarf individuals survive in the first generation, in a possible second sexual generation, and in subsequent generations, they will probably be finally eliminated. In the first paper, it was suggested that dwarfness is recessive to tallness. The small number of dwarf hibiscus which are produced compared with the tall and the fact that the dwarfs are naturally eliminated in competition with the tall individuals might account in part for the rareness of the dwarf type. The chance of this type surviving would depend upon its being removed from competition and therefore on its having some ornamental qualities to recommend it for artificial selection.

ARTIFICIAL SELECTION

A number of the dwarf plants in the College cultures were able to reach their flowering age. It so happened that their flowers were attractive in a number of respects, in shape and color for example, and as the authors desired to save them for this reason, they were potted and taken where they could be given particular attention. This better care consisted only in watering the plants often enough to keep the soil in the pot moist. They were not even specially fertilized although the soil used to fill the space in the pots came from a place supposedly rich in organic matter. During the dry season, it was necessary to water the plants once a day. Had the plants which died flowered, producing desirable flowers before they perished, this production of beauty might have led to their being saved by potting and subsequent care.

The results obtained by potting suggest that in a commercial culture of hibiscus seedlings, it would be advisable to separate the dwarf and otherwise weak plants from the taller and more vigorous ones and to grow them under more favorable conditions. Even at the risk of potting plants whose flowers are not especially beautiful, one should not wait for these dwarf plants to flower, as most of them might die before reaching the age of reproduction. No matter if they will produce flowers similar to those of their tall or medium companions, they are worth saving for pot culture purposes. The tall type is very undesirable for growing in pots.

THE DWARF AND MEDIUM HIBISCUS SEEDLINGS AS POT ORNAMENTALS

In the third year of life of the seedling the authors cultured some twenty of the dwarfs in pots for a year; so far, none of the plants has died. On the contrary, they appear healthy, healthier than the plants not potted and some of

them have produced from one to four flowers most of the time since they began to bloom in the pot. In this year of life in the pot they have grown hardly any taller. All these observations tend to show the adaptability of dwarf hibiscus seedlings for pot cultures.

As potted hibiscus seedlings are almost unknown in the Philippines, especially the dwarf variety, the potted seedlings under report have attracted no little attention from plant lovers. It should be mentioned that floriculturists in Manila occasionally offer potted hibiscus for sale, but these are of the tall, native variety, and their tall lanky appearance do not make them attractive pot ornamentals (see Figure 2). On the other hand, the dwarf varieties, such as those grown in this study, have the short stature and compact growth which one is apt to look for in a potted plant (see Figure 1). The tall varieties in the pot do not produce as many branches as the dwarf and therefore they do not produce flowers as frequently and in such abundance. An interesting characteristic of some of these dwarf plants is their occasional production of miniature flowers which are not distorted like those attacked by insects at their bud stage but which are perfectly normal except as to size. Another interesting habit shown by some hibiscus plants of not only the dwarf, but also of the medium and tall types, is that the shade of color in the flower changes slightly as the plants become older. One change was from light yellow to deeper yellow. It would be interesting and of commercial importance to determine how much of the dwarfness exhibited by first generation seedlings is transmissible to first and subsequent generations of plants raised by cuttings or by other vegetative means. It is only to be suspected that this dwarfing is hereditary. However, it may also be possible that this dwarfing came about partly as a result of stunting influences exerted by the environment on the plants when they were very small, much smaller than any young plant that generally can be grown from cuttings.

The seedlings which are intermediate in height between the dwarf and the tall types may be grown in pots, also, although they thrive under less care than the dwarf varieties. If these larger types are potted, pots larger than 9-inch pots should be used. Grown alone, these medium seedlings do not present as beautiful and as attractive an appearance as the dwarf kinds, not that they produce fewer flowers, but they seem fewer because of the larger size of the plant. However, potted medium tall plants properly placed among potted dwarf plants, produce a very attractive combination, being less monotonous than a group composed wholly of dwarf varieties.

A word or two may be added in favor of ornamental hibiscus plants as compared with other flowering plants. As hibiscus blooms only for a day (varieties which bloom for two or more days are known but are rare) and new flowers are produced constantly there is in the hibiscus a daily freshness which is not found in flowers which last for several days; as for example, roses. Then also, if one has ten, twenty, or more hibiscus plants of different flower colors, he is likely to get a different combination of colors every day. One day, he may have white-yellow-rose combination, another day he may have the pink-near-blue-orange color grouping. One shortcoming of the hibiscus flowers is their lack of fragrance. But there are fragrant varieties. In fact, in the authors' cultures, there is a variety with a fair amount of sweet odor in the flower, and it may be that as a result of natural selection or artificial efforts a variety as fragrant as the rose may yet be evolved.

The authors desire to express their thanks to Mrs. Mendiola who gave much attention and care to the potted dwarf hibiscus discussed in this paper.

Fig. 1

Fig. 2 (a) (b) (c) (d)

PLATE I

Fig. 1 Potted Dwarf Hibiscus.
Fig. 2 (a) and (b) medium tall variety grown directly from seeds.
(c) A dwarf seedling.
(d) A plant of the tall seedling variety grown from a cutting.

IMPACTION OF THE CROP CAUSED BY CANDLES[1]

By Miguel Manresa

Of the College of Veterinary Science

On November 24, 1923, a valuable fighting cock was brought to the Small Animal Clinics of the College of Veterinary Science with the complaint that it had not eaten anything for eight days, had lost considerable weight, and had not been able to empty its crop. The fowl appeared dull and its comb and wattles were very anemic. Its temperature was normal. The crop was found distended, and on palpation, firm hard bodies could be felt. Impaction of the crop was diagnosed. By impaction of the crop we mean that condition characterized by obstruction or occlusion of the dilated portion of the esophagus called the crop The ingested material is retained in the crop for a long time and not passed to the proventriculus and gizzard.

The treatment prescribed in this case was powdered nux vomica in ten-grain doses to be given twice daily. For convenience in treatment and observation, the bird was confined in a cage. The following day, November 25, it passed watery feces but its crop was as firm as the day before. The crop was massaged carefully and the treatment repeated. On the third day as the treatment failed to effect evacuation an operation was performed. Among the impacted material two pieces of paraffin about the size of the thumb attracted attention. One of these pieces was securely wedged in the opening of the crop into the proventriculus.

Paraffin and other substances of similar nature have not been reported, so far as the author knows, as causing any obstruction of the crop among fowls. Candles of tallow, wax, spermaceti, and paraffin are common household articles in Filipino homes. They are used to furnish light for tables, halls, and churches. Thousands of them are lighted annually in the streets during religious processions. On All Saints' Day, which occurs in November every year, most of the cemeteries in the Philippines are ablaze with candle light. This extensive use explains why pieces of candles are found promiscuously about the yards and in the streets and are picked up by the fowls running at large.

During the last two years we have received at the Small Animal Clinics of the College of Veterinary Science several fine cocks, as well as hens, suffering from impaction of the crop. In a great majority of these cases these candle materials were found mixed with the impacted material.

The frequency of these cases is the excuse that the writer desires to offer for making an inquiry into the nature of impaction that they produce. It may be asked at the outset: To what extent will fowls pick up pieces of candles? It is pertinent to ask this question in view of the fact that with the possible exception of tallow candles, the other kinds of candles do not have any food value.

A series of experiments were conducted in the barrios of Batong Malaki and San Antonio for the purpose of inquiring into this phase of the subject. It was found that: (a) Fowls picked up pieces of candles both accidentally and

[1] Experiment Station contribution No. 225.

voluntarily; (b) Tallow was the most relished, and paraffin the least; and (c) When very hungry the fowls engorged themselves with pieces of these materials to the extent of producing impaction.

REVIEW OF LITERATURE

Ward and Gallagher (1) are authorities for the statement that impaction of the crop will cause death of the fowl in a few days if the condition is not remedied.

According to Hutyra and Marek (2) impaction of the crop is frequently due to the overfeeding of more or less indigestible foods, such as corn, peas, and straw; or to the ingestion of foreign bodies, such as pieces of metals, stones, pieces of glass, bones, and fragments of egg shell. The presence of parasites in the crop may also cause the condition.

Pearl, Surface, and Curtis (3) attribute the condition to two immediate causes; namely, (a) Paralysis of the thin muscular walls of the crop due to overdistention with dry grains, and to the low vitality of the animals as a result of acute disease or improper nourishment; and (b) The clogging of the lower portion of the esophagus by long straws, feathers, and other substances.

Kaupp (4) reports that potato parings given to incubator-hatched and brooder-raised chickens caused fatal impaction in two cases; and Law (5) states that certain foods containing paralyzing elements, such as *Lolium temulentum*, chick vetch, etc., are to be especially dreaded.

EXPERIMENTS

That a more definite knowledge might be obtained regarding the nature of impaction induced by the ingestion of pieces of candles, the following experiments were conducted. In these experiments the following materials were used:

Paraffin candles.—Those sold at the local market under the name of "El Sol Claro," manufactured by Lit Eng & Co., Manila.

Tallow candles.—Manufactured by C. Chin Lim, Manila.

Wax.—White beeswax (*Cera Alba*). Shoemaker and Bush, Philadelphia, Pa., sold in circular disks about 10 centimeters in diameter and one centimeter thick.

These materials were cut up into varying sizes and shapes and were fed the fowls by force. The fowls were then confined in cages and the results carefully noted.

EXPERIMENTS WITH PARAFFIN CANDLES

Experiment No. 1.—Subject: Cantonese pullet, in good condition.

History: On December 3, 1923, at about 8 a. m., this fowl was fed pieces of paraffin candle, cut the size of a grain of corn, making about 5 grams weight in all. These pieces were fed on an empty crop. The fowl was not allowed feed the rest of the day.

Results: When examined the following morning, the crop was completely empty.

Experiment No. 2.—Subject: Cantonese cockerel, in good condition.

History: On December 3, 1923, at about 8 a. m., this cockerel was fed pieces of paraffin candle cut the size of a grain of corn, making about 5 grams weight in all. These were fed on a full crop. The fowl was not allowed feed the rest of the day.

Results: When examined the following day, the crop was found completely empty.

Note: An attempt to recover the paraffin from the droppings of the fowls used in these two experiments proved successful.

Method: The droppings during the night were collected, stirred in proper amount of water, and boiled on water bath for about 30 minutes. Then it was allowed to cool slowly, and after 24 hours the paraffin could be recovered from the surface of the water.

Experiment No. 3.—Subject: The cockerel used in Experiment No. 2.

History: On December 4, 1923, a. m., this fowl was fed pieces of paraffin candle the size of a grain of corn on an empty crop. Then it was confined and allowed abundant feed.

Results: When examined 9 hours after feeding the paraffin in larger pieces than those which were fed could be felt in the crop, showing that the small pieces had softened and coalesced, forming a soft mass. This soft mass persisted in the crop for two days but was passed eventually.

Experiment No. 4.—Subject: Native white spotted hen, in good condition.

History: On December 6, 1923, p. m., this hen was fed pieces of paraffin in circular disks about 10 millimeters in diameter and 5 millimeters thick. These were fed on an empty crop.

Results: On the morning of the following day the paraffin in the crop had formed into a single mass, soft and easily molded. This mass persisted in the crop until December 9, but was eliminated eventually.

Experiment No. 5.—Subject: The pullet used in Experiment No. 1.

History: This pullet was allowed a mixture of feed consisting of unhulled rice (palay), crushed corn, and rice bran in equal proportions, and when the crop was almost full it was fed pieces of paraffin candle the size of sword beans (*Canavalia ensiformis*) on December 8, 1923.

Results: The following day the crop was well distended and hard. The pullet was allowed to run about on the lawn. It had no food except what it could pick up on the lawn. The bird was confined at night, and when examined the following day no reduction in size of the crop had taken place. No feed was given this day. On December 11, slight reduction was noted, and on the morning of December 12, the crop was completely empty.

Experiment No. 6.—Subject: The cockerel used in Experiment No. 2, in good condition.

History: On December 8, 1923, this cockerel was fed pieces of paraffin the size of sword beans on an empty crop. The bird was confined in a cage without feed for about eight hours, after which time it was offered some palay (unhulled rice) which was not well relished.

Results: On the morning of December 9, the crop was firm and well distended. Feed was kept in the cage although the bird partook of it sparingly. Palpation of the crop, made December 11, showed the presence of practically pure paraffin. On the following day the bird appeared to be drowsy and weak. It sat most of the time with the neck bent hiding its head in its feathers. Bread crumbs or whole grains of corn offered were not taken. On December 13, it was

decided to relieve the impaction. The paraffin was carefully molded with the fingers into an elongated mass and was slowly worked back through the mouth. Considerable difficulty was met. But after a long trial, removal was effected. The bird then improved rapidly.

EXPERIMENTS WITH WAX

Experiment No. 1.—Subject: Five-month old Cantonese pullet, in good condition.

History: On December 15, 1923, this pullet was fed pieces of wax the size of a grain of corn. These were fed on an empty crop. The pullet was not allowed any feed the rest of the day.

Results: When examined on the morning of the following day the crop was completely empty.

Experiment No. 2.—Subject: A Cantonese cockerel, in good condition.

History: On December 15, 1923, pieces of wax the size of a grain of corn were fed this cockerel on a full crop. The cockerel was allowed feed during the day.

Results: On the morning of the following day the crop was completely empty.

Experiment No. 3.—Subject: The pullet used in Experiment No. 1, in good condition.

History: On December 16, 1923, this pullet was fed a mixture of chicken feed consisting of palay, crushed corn, and rice bran, and when the crop almost full it was fed three pieces of wax the size of one's thumb. Palay and corn feed were given daily.

Results: On the morning of the following day the crop was firm and well distended. The pieces of wax could be determined by palpation. The pullet did not appear to be bothered at all by the wax in the crop, so it was given feed daily and placed under observation. On December 22, it looked dull and tired. It stood still most of the time with folded neck and hid its head in its plumage. On December 23, it did not feed any and appeared a bit worse. An attempt to remove the pieces of wax by way of the mouth proved fruitless. For that reason an operation on the crop was performed. The pieces were removed with ease, after which the interior of the crop was washed with one per cent creoline solution, and the wound closed using double sutures. Recovery was rapid.

Experiment No. 4.—Subject: The cockerel used in Experiment No. 2, in good condition.

History: On December 16, 1923, this cockerel was fed ten pieces of wax the size of sword beans on an empty crop. Feed was withheld for a period of two days but water was allowed.

Results: Up until December 19, complete passage of the material in the crop did not occur. Palpation showed that the wax was not rendered soft. The bird was turned loose in the yard and given palay (unhulled rice) and corn as feed. The following day the crop was apparently empty. Palpation did not reveal any material in the crop. The cockerel, however, did not appear to be lively and touched feed sparingly. The crop was opened December 21; a piece of the wax was found wedged in the proventriculus.

EXPERIMENTS WITH TALLOW CANDLES

Experiment No. 1.—Subject: A female Cantonese chicken, in good condition.

History: This bird was received January 3, 1924, with a full crop. Immediately, it was fed about 5 grams of the so-called tallow candles in small pieces.

Results: On January 4, the crop was hard. When pressed between the fingers the contents felt like a piece of stone. Considerable pain was manifested when the crop was handled. From January 5 to 6 no reduction in the size of the crop was noticed. No feed was taken during these two days. On January 7, the crop was a bit smaller than on the days previous. The bird took feed and continued to be lively until January 11, when it looked much depressed. Its wings hung and the feathers were rough. Palpation revealed the presence of a firm mass of food the size of a walnut in the crop. Pressure on this mass produced pain. The bird took very little feed. As treatment, 10 cc of coconut oil was administered. No improvement was noted on the following day, January 12, on the contrary the chicken seemed in a worse condition. It sat on its breast most of the time. Its temperature was 39.5°C. An incision on the crop was made. The impacted material, which consisted of palay, whole corn grains, and tallow firmly compressed into a single mass, was removed.

In closing the wound a single continuous suture was used. No improvement was noted during the two days that followed. The wound was dry. Meanwhile considerable weight had been lost. The temperature decreased, being 38.9°C. on January 13 and 38.3°C. on January 14. Bread crumbs and milk were fed by force. On January 15, the temperature was 37.7°C. The droppings became soft, watery, and yellowish.

The wound had dried and healed completely. On January 16 death was imminent. The temperature was 36.7°C. The bird died before noon on January 17, 1924.

Experiment No. 2.—Subject: A male Cantonese chicken, in good condition.

History: This chicken was received January 3, 1924, with a full crop. It was fed immediately about 5 grams of the so-called tallow candle in small pieces. Usual feed and water were allowed during the progress of the experiment.

Results: From January 4 to 11 the crop remained fully distended and contained a solid mass of feed, but the chicken continued to be lively and consumed its feed. The temperature varied between 41.5°C. to 42.2°C. during this period. On January 12, however, the bird appeared a bit dull. The plumage was somewhat ruffled. The impacted material which persisted in the crop was carefully broken into smaller portions using slight finger pressure from the outside. On January 13, the impaction was not relieved. The condition of the chicken grew rapidly worse. The temperature dropped to 39.5°C. The impacted material was removed through an incision made on the upper portion of the crop. In closing the wound a single continuous suture was used. On the following day the wound appeared to be healing nicely, but the temperature was 39.°C. and the chicken sat most of the time and did not touch the soft feed offered. When let loose in the yard it secluded itself in corners. Bread crumbs and milk were fed by force. The bird died on January 15, 1924.

SUMMARY

The ingestion of pieces of paraffin candle, and the so-called tallow candle induces impaction of the crop. The impaction so induced is brought about by the fact that the pieces ingested soften inside the crop. When these soft pieces are compressed by the contraction of the muscular walls of the crop they coalesce forming a large solid mass the passage of which is either very difficult or impossible.

Wax is not rendered soft in the crop but when of large size it clogs the lower portion of the esophagus.

Experiments conducted with the pure beef tallow proved that this substance is easily disposed of in the crop. The danger, therefore, lies in picking up substances that are rich in wax and paraffin.

SYMPTOMS

The first indication of impaction is marked dullness and loss of appetite. The fowls become weak rapidly. They sit most of the time, and in advanced cases try to hide the head in the plumage by bending the neck. The most significant symptom is the persistence of a firm and fully-distended crop which is sensitive to the touch during the early stages and which becomes pendulous and non-sensitive after the walls are paralyzed. Palpation may even reveal the consistency of impacted material. The temperature is not elevated but becomes subnormal as the condition becomes aggravated.

PROGNOSIS

Favorable, provided treatment is given early before the fowl has become greatly debilitated.

RECOMMENDATION

TREATMENT

By far the best treatment is surgical interference consisting of making an incision in the crop at its upper portion. The impacted material should be removed and the wound sutured with a single continuous suture, after the crop has been carefully washed with a mild antiseptic. The after treatment consists in allowing the bird soft feed for about two days. Under proper conditions the wound heals rapidly and the sutures may be removed in from two to three days.

PREVENTION

Fowls do not have a well-developed sense of taste and when very hungry are likely to pick up almost anything that looks like food. Consequently where valuable fowls are kept, pieces of paraffin and wax candles should not be thrown on the ground around the houses.

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ABSTRACT[1]

A study of the relation of different amounts of water supply to growth, straw, and seed production of rice, R. A. Reyes. (*Thesis presented for graduation from the College of Agriculture No. 179; Experiment Station contribution No. 226*). —In this study the author dealt with growth, straw, and grain production of both lowland and upland varieties of rice with reference to water supply His object was "to find out the amount of water necessary to make certain varieties of rice produce a maximum yield". The cultures were grown in petroleum cans with soil at different saturations—as 100 per cent plus depth of one centimeter of water, 90 per cent, 67 per cent, 45 per cent, and 22 per cent of saturation. High percentage of moisture gave the high yields of straw and grain, and low percentage of moisture gave markedly low yields. All the plants in all the cultures failed to head out in 22 per cent supply of water. Lowland rice did not produce a good yield of grain in 45 per cent moisture. It was found that there was a wide difference in the moisture requirements of upland and lowland varieties of rice, and that the amount of water needed for heavy grain production was directly proportional to the yield. In rich soil, tillering was more abundant than in poor soil.

Iroy (lowland) was the highest producer of grain and straw. Kinirispino (upland) was the second heavy grain yielder. Bonget (upland) was the poorest producer of grain and straw.

Abstract by Gregorio B. Lontok.

[1] Abstract prepared as part of required theme work in English 101, College of Agriculture.

COLLEGE AND ALUMNI NOTES

In the College Summer School, in session from March 24 to May 30, the enrollment was 366. This is the largest summer school enrollment in the history of the College.

Captain Arthur H. Phillips, Headmaster of the Queen Victoria Memorial School, at Suva, Fiji, visited the College of Agriculture, March 10 to 18. Captain Phillips expressed great interest in the system and problems of the College and intimated the possibility of employing graduates of the institution in the furthering of elementary education in other tropical countries. While in the Islands he inspected the entire educational system in detail and at first hand, especially the agricultural schools at Trinidad and Muñoz.

Prof. H. Otley Beyer with Mr. Overbeck of Java visited the Campus on April 13. Professor Beyer is head of the Department of Anthropology and Sociology in the University. Mr. Overbeck, a business man, has for his avocation Malayan poetry and folklore. He has published valuable contributions on these lines.

Prof. E. Gertrude Madison of the English Department has prepared during the summer session a card catalogue of the PHILIPPINE AGRICULTURIST from Volume 1 to XII, inclusive. This card catalogue may be consulted, not only for the authors of the articles published, and for the subject of the papers but also for the outstanding elements given in the titles. The library committee believes this addition to the consulting equipment will be of service to students, to faculty, and to alumni.

The Los Baños Biological Club closed its first year with its third scientific meeting on February 26, 1924, at which papers were read by Dean C. F. Baker, Dr. Miguel Manresa, and Dr. Angel K. Gomez. In the business meeting which followed Dr. B. M. Gonzalez was unanimously re-elected president and Dr. L. B. Uichanco, secretary, for the ensuing term.

The Club had no sessions during the summer term but will resume its activities at the opening of the College year in June. Drs. F. O. Santos, R. L. Pendleton, N. B. Mendiola, G. San Agustin, Prof. D. A. Herbert and other workers have promised to discuss subjects along their respective lines of investigation.

A copy of *Farthest-North Collegian*, Volume 1, No. 1, the publication of the Alaska Agricultural College and School of Mines was recently received. This College, probably the youngest under the American flag, was opened September 18, 1922. It is located at Fairbanks, Alaska. To make good its claim to being farther north than any other institution of higher education in the world, the *Collegian* gives 64° 51′ 21″ as the latitude of the college building.

The contents of the journal includes articles on "Coal deposits in Healy River," "Agricultural Economics in Alaska" and on other phases of the college work. Athletics and the Student Association are given prominence.

"One acre of land in Interior Alaska will raise more vegetables than will four in the States and do it in half the time."

"Mrs. Bruce, the first graduate student to enroll in the college, has chosen the improvement of the blueberry as her research problem."

"The Board of Trustees recently approved a course of study in Reindeer Management."

These quotations from the *Collegian* are given to indicate trend of work in the College. It may be added that one member of the Board of Trustees is a woman.

As the College of Agriculture "farthest south" under the Stars and Stripes we hail our northern sister and wish her success.

Mount Maquiling Echo, Nos., 1 and 2, the Forest School quarterly publication in mimeograph, is a most interesting number. Among the articles are: "Relative Durability of Native Woods," "Geology and Soils in Relation to Forestry," "Fish Ponds in the Swamps". Many notes on the work both in the field and in the school give it a distinct news value.

The Index of Volume IX of the Philippine Agriculturist is now in print. This index was prepared by Dr. F. M. Fronda of the Department of Animal Husbandry.

The manual "Preparation of Thesis and other Manuscripts" by Dr. S. F. Trelease and Prof. Emma S. Yule has been revised by the authors and will be published under the title "Preparation of Scientific Papers" this fall in book form by Williams & Wilkins Company, Baltimore.

Under the initiative of Dr. B. M. Gonzalez, a kindergarten is to be opened on the Campus about June 1 for the benefit of the children of the faculties. It is hoped eventually to add higher grades.

While nothing extensive in buildings has been added to the College this past year, some needs have just been completed. The Silk House has been transformed into a commodious Soil Technology Building. A large and convenient Tool and Implement Building is partially constructed. Animals slaughtered for meat are now cut up and the product sold in the new Butcher Shop of the Animal Husbandry Department. This department also boasts a new Central Poultry House adjoining the Old Animal Husbandry Building. It has an incubator cellar, a killing room, a feed room, a sales room, enclosures for both artificial and natural brooding, a hospital for sick birds and a room for the incubator attendant. The College contributed the materials for this building, while the newly created revolving fund of the Animal Husbandry Department paid for the labor. All buildings on the lower campus have been painted on the outside, including the roofs. The intake of the water system has been entirely rebuilt. The four temporatory nipa dormitories have been condemned and torn down.

Mr. Joaquin Arana, Farm Engineer, was in charge of all construction.

A building epidemic has broken out in the faculty. Doctors Gonzalez and Vibar and Professor Adriano are making new houses out of their old. And Professor Hester, Doctor Roxas and Professor Raymundo are making changes in their residences.

The College sugar mill closed its second milling season March 31. The season was successful. Doctor Roxas reports 367 tons of cane ground with an operative net profit of ₱2,200.00, sufficient to pay for the growing of the cane on the College Farm. A full report will be published in the next number of the PHILIPPINE AGRICULTURIST. The closing of the mill was celebrated by a reception at the residence of Doctor Roxas.

The Animal Husbandry Department has just acquired Hassan, a mestizo Arabian stallion, a horse famous on the San Lazaro race track. The animal is six years old, stands 53.5 inches (135 cm.) high, and is gray in color He has a record of 3′ 15″ for one and one-half miles made at San Lazaro on February 3, 1924, while carrying a weight of 115 lbs. (52 kg.) The animal was bred and raised in Lipa, Batangas, and is the get of Governor Forbes' renowned polo pony of the same name, which he donated to the Bureau of Agriculture. Hassan will be used to head the College stud. The price paid was ₱1,000.

Prof. D. A. Herbert, accompanied by Mrs. Herbert, spent three vacation weeks in China.

Mr. Leon G. Gonzalez, '22, was married to Miss Sara Gonzalez of Baliwag, Bulacan, at the Paulists church on Calle San Marcelino, Manila, April 12, 1924.

Mr. Daniel B. Peña, '22, assistant in Animal Husbandry, resigned to accept a position with the Far Eastern College in Manila.

Mr. Valeriano M. Sarmiento, assistant in Plant Pathology, resigned. He sailed on the S. S. *President Jefferson* April 6, 1924, for the United States. Mr. Macario Palo '24 has been appointed in his place.

Mr. Eusebio A. Bataclan, '24, was recently appointed assistant in mathematics.

Mr. Alfonso Hilado, instructor in mathematics, was on leave during the summer session.

Miss Emilia Maramba, sister of Mr. Felix D. Maramba of the Department of Rural Engineering, matriculated in physics for summer session. Miss Maramba lived with her sister, Mrs. Henares, on Faculty Hill.

The College of Agriculture Alumni Association contributed ₱100 to the Independence Fund drive.